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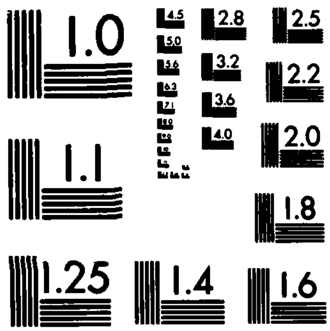

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This report is a problem definition study describing the potential adverse human health effects associated with all aspects of Field Water Supply and Field Sanitation. It outlines present doctrine and knowledge gained from field interviews and from a review of the military and published literature. Potential data gaps and research needs are identifed. Appendices A and B of this report are separate volumes which contain summary field interview reports and a bibliography, respectively. The Appendices are for official use only (For availability see explanatory notes b, c, page 186).

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RESEARCH AND DEVELOPMENT FOR HEALTH AND ENVIRONMENTAL HAZARD ASSESSMENT - TASK ORDER 2

Problem Definition of R and D Requirements for Field Sanitation and Water Supply

Final Report

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A. FIELD INTERVIEW REPORTS

B. BIBLIOGRAPHY

FOREWORD

Citations of commercial organizations and trade names in this report do not constitute an official Department of the Army endorsement or approval of the products or services of these organizations.

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Defense Pest Management Information Analysis Center

US Agency for International Development

US Army Academy of Health Sciences

US Army Chemical Systems Laboratory

US Army Cold Regions Research and Engineering Laboratory

US Army Construction Engineering Research Laboratory

US Army Deputy Chief of Staff for Logistics

US Army Engineer School

US Army Engineer Topography Laboratory

US Army Engineer Waterway Experiment Station

US Army Environmental Hygiene Agency

US Army, Europe

US Army Forces Command

US Army Health Services Command

US Army Logistics Center

US Army 224th Medical Detachment

US Army Medical Intelligence Information Agency

US Army Mobility Equipment R&D Command

US Army Natick R&D Command

US Army Office of the Chief of Engineers

US Army Office of the Surgeon General

US Army Research Institute for Environmental Medicine

US Army Training and Doctrine Command

US Army XVIII Airborne Corps

US Marine Corps Air/Ground Combat

US Navy Bureau of Medicine and Surgery

US Navy Civil Engineering Laboratory

Uniformed Service University of Health Sciences

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R chard P. Schmitt	V. J. Ciccone and Associates, Inc.

LIST OF ACRONYMS

The following are a list of acronyms used in this report.

Abbreviation	Full Title
MRDC	Medical Research and Development Command
DOD	Department of Defense
NBC	Nuclear, Biological Chemical
MIIA	Medical Intelligence Information Agency
CERL	Construction Engineering Research Laboratory
CSL	Chemical Systems Laboratory
MERADCOM	Mobility Equipment Research & Development Command
NARADCOM	Natick Research and Development Command
RIEM	Research Institute for Environmental Medicine
WES	Waterway Experiment Station
MBRDL	Medical Bioengineering Research & Development Laboratory
EHA	Environmental Health Agency
AHS	Academy of Health Sciences
OTSG	Office of the Surgeon General
TRADOC	Training and Doctrine Command
USUHA	Uniformed Services, University of Health Sciences
CRREL	Cold Regions Research and Development Command
FORSCOM	Forces Command
HSC	Health Services Command
OCE	Office of the Chief of Engineers
DSCLOG	Deputy Chief of Staff for Logistics
TSA	Troop Support Agency
DPMIAC	Defense Pest Management Information Analysis Center
ETL	Engineer Topographic Laboratory
CEL	Civil Engineering Laboratory
AID	Agency for International Development

I. EXECUTIVE SUMMARY

A. Overview of the Study

Field Water Supply and Field Sanitation are areas of major concern for the Army. The Army medical community consequently places strong emphasis on the practice of preventative medicine in these areas because they impact directly on the health, efficiency and morale of the individual soldier. Over a period of years, the Army Medical Research and Development Command (MRDC) has been involved in many programs to meet the Army's requirements and more recently has recognized the need for a comprehensive review of these subjects.

This report is intended to fill that need. Its objectives are:

- to document current doctrine, practices and trends
- to discuss potential health effects for the individual soldier and larger units
- to identify gaps in the documentation and areas in need of further research and development work.

Documentation of the available information was approached in two ways:

- First, by an extensive field interview program designed to contact those Army functions who are responsible for, or involved in, field water supply and field sanitation (to the extent possible within the time and budget constraints);
- Second, by a comprehensive literature review covering published literature, Army and other DOD manuals and reports and informal Army communications.

Appendices A and B to this report consist, respectively, of summary field interview reports and a bibliography derived from literature review. (The appendices are for official use only. Requests for them may be directed to: US Army Medical Bioengineering Research and Development Laboratory, Environmental Protection Research Division, ATTN: PAM, Field Sanitation and Water Supply, Fort Detrick, Frederick, MD 21701.)

Data gaps and research needs that are identified in the body of the report result from study and observations of the project team and from observations described by Army personnel during the field interviews. We have not identified these two sources separately, but certainly wish to acknowledge a major contribution of these ideas from the field. It was required that the data gaps or research needs would not be ranked in any way, this task is clearly the perogative of the Army Medical Research and Development Command.

In the body of the report, Field Water Supply (Section III) and Field Sanitation (Section IV) are discussed separately. Each section is divided into major subject areas as follows:

Field Water Supply

A. Water Sources
B. Water Consumption
C. Water Quality (Potable Water)
D. Detection and Analysis
E. Water Treatment
F. Transportation, Storage, Distribution

Field Sanitation

A. Personal Hygiene
B. Human Waste Disposal
C. Food Service Operations
D. Medical Waste
E. Waste Products

Each major subject area is divided into a number of topics which relate to a set of operational environments and operational characteristics. For example, Section III C, Water Quality, is a major subject area which is divided into the following topics:

- Distribution of Water Borne Pathogens
- Environmental Contaminants/Opportunity Poisons
- NBC* Contaminants
- Palatability of Drinking Water
- Recycle/Reuse Considerations

The format for each topic has been standardized as far as possible to present the information under a set of common headings.

- Requirements (Criteria, Procedures, Effectiveness, Field Experience)
- Potential Health Effects
- Documentation of Information Sources
- Data Gaps and Research Needs

The report is designed to provide information on field water supply and field sanitation in two ways. First, as a documented guide for USAMBRDL and MRDC to identify research and development needs of the Field Army, and second, as a source book of categorized and readily accessible information covering the subject areas. Under the second heading, it is expected to find important uses within the Army's Operational Preventive Medicine organizations.

The information included in the report represents all that could be obtained and assessed during the time frame of the study, August 1980 to April 1981, and was somewhat restricted by budgetary limitations. In retrospect, there are clearly other sources which may have relevant information. In some respects the coverage may appear unbalanced: for example, there is a greater emphasis on hot, arid climates which reflects the availability of information and the current military emphasis. However, the lack of information on other environments such as "hot tropical" or "arctic" of itself indicates a potential research need and is generally so indicated.

B. Research and Development Needs

This study has identified a number of areas within the scope of Field Water Supply and Field Sanitation that are clearly health related problems worthy of

*Nuclear, Biological and Chemical

Medical R & D attention. The problems and needs most frequently expressed and discussed are highlighted below without implying any ranking or priority. Further supporting information can be found in the appropriate areas of text.

Two general ideas have emerged which are applicable to Field Water Supply and Field Sanitation.

- There is a need to establish an easily accessible data bank, specific to Preventive Medicine (PM) personnel. The need was expressed at all levels of organization, from the DA staff down to the Division level. It focussed upon the inability of PM personnel to, quickly and accurately, retrieve data pertinent to Preventive Medicine planning and operations in various regions of the world where the U.S. military may have to operate. It was suggested that other military based data banks exist (such as those at USAMIIA and AFPMIB), which can serve as the model (if not the operand) for the proposed PM data bank. The information presented in the body of this report can serve as the foundation for such a data bank, but a more detailed presentation is required for PM personnel.

- It was a major concern that there are no techniques, tools or methodology that will allow Field Preventive Medicine personnel to make confident reliable RISK ASSESSMENTS of real or potential health hazards, under actual combat conditions. The Army health professional in the field requires a means to quickly conduct risk assessments, which will allow him to better evaluate selected situations and make recommendations (decisions) relative to expected or predicted casualties, incapacity or loss of efficiency in the fighting force.

Specific areas of need identified from this problem definition study are identified below under the headings of Field Water Supply and Field Sanitation.

Field Water Supply

- A critical need exists to develop a comprehensive set of Field Water Quality Criteria, based upon scientific data which accurately reflects the unique characteristics of a military population, TB MED 229, is questioned on its applicability to a military combat population and/or situation in terms of contaminant concentrations, time of exposure and total intake quantities. Hence, there is a need for a thorough review of appropriate available toxicological data bases and the subsequent development of criteria applicable to the military - under Field Combat Conditions.

- The accurate detection and measurement of water quality criteria parameters under combat conditions was consistently mentioned as a concern. Of special interest is the limited ability to evaluate and assess water contaminated with chemical agents, especially in relation to enhanced consumption in hot-arid regions. Consequently, the current technology (colorometric), specific equipment, reagents (pre-packaged), and levels of detection (especially for chemical agents) were identified as major areas for research and development.

- Adequate disinfection of field water supplies was identified as an area of concern. This included the development of alternatives to chlorine as a disinfecting agent and new detection and measurement techniques to confirm adequate disinfection. Potential research and development needs are a final field evaluation of Free Available Chlorine (FAC) test with Syringaldazine; waiting periods for disinfection; evaluation of state-of-the-art disinfection technology; better disinfection indicators; and the development of a substitute for the iodine water purification tablet.

- Procedures to facilitate timely selection of the best available water source need to be revised and further developed, considering available treatment processes and distance from the points of consumption.

- More extensive doctrine and guidance on water consumption rates is required for all levels of activities and climates. It should be related to the known physical and chemical characteristics of the available water.

- Increased guidance and surveillance of water distribution operations and water quality requirements is necessary, especially in the arid regions where conservation and potential wastewater reuse are important considerations.

- The reclamation and reuse of wastewaters for non-potable requirements in water-scarce combat theaters has received much recent attention within the military. It is documented that present treatment technology can economically and reliably reclaim wastewaters for non-potable reuse (see MERADCOM research reports), however, adoption of the technology by the Army is contingent upon development of health-based "reuse" water quality criteria and subsequent promulgation by the Surgeon General.

An abbreviated listing of specific or cooperative research elements identified under the heading of Field Water Supply is provided in Table 1.

TABLE 1

WATER SUPPLY R&D REQUIREMENTS

WATER SOURCES

- Develop data bank of water quality and quantity for worldwide locations.
- Improve techniques for locating groundwater sources, particularly in extreme climates
- Develop improved techniques for utilization of groundwater in tactical operations.

WATER CONSUMPTION

- Determine minimum and desirable water requirements, potable/non-potable, for all operational situations and climatic conditions.
- Determine quantities of water needed specifically for NBC decontamination.
- Establish palatability requirement for situations where enhanced consumption is necessary.

WATER QUALITY

- Update and expand the drinking water criteria and standards relative to consumption rates under different conditions.
- Provide more extensive guidance on the probability of occurrance and distribution of water-borne pathogens in different theaters of operation.
- Review guidance on probabilities of NBC contamination of water sources.
- Determine the health effects from the combinations of disinfectants and artificial flavors which may be used to enhance palatability.
- Define requirements for cooling water in hot climates.
- Develop water quality criteria and standards for non-potable recycle/reuse.

DETECTION & ANALYSIS

- Improve procedures and equipment for field water testing, particularly the measurement of free available chlorine (FAC) in the field and by individuals.
- Validate the acceptability of field detection of NBC agents and if appropriate develop simple detection methods suitable for small units.

TABLE 1
(continued)

- Identify and rank a list of industrial pollutants and investigate simple methods for their detection.
- Develop a colorimetric pH measurement for seawater.

WATER TREATMENT

- Study the health affects of short-term iodine consumption consistent with the enhanced drinking water requirements in hot climates.
- Perform disinfection studies of resistant bacterial, protozoan and viral species.
- Investigate methods to maximize palatability using individual treatment.
- Investigate substitutes for chlorine water disinfection.
- Investigate new disinfectants compatible with reverse osmosis membranes.
- Determine health impacts in bypass of RO membranes with fresh water sources.
- Develop methods of NBC wastewater disposal & equipment decontamination.

DISTRIBUTION AND STORAGE

- Improve capability to determine potability and palatability of water from distribution systems.
- Identify leachates of health significance from storage and distribution facilities.
- Establish health related requirements for cooling water.

Field Sanitation

The requirements for additional medical research in the area of field sanitation focus generally on upgrading and broadening the application of current field expedient procedures which have been used by U.S. military forces since World War II. Specific problems which were identified include the following:

- A major concern was Waste Disposal Procedures and practices in arctic and in hot-arid regions. The effectiveness of current field sanitation technology to eliminate potential health problems was questioned in connection with the disposal of: human wastes, kitchen wastes (proper cleaning and sanitizing of bulk food pots and pans), and industrial type wastes (pesticides, solvents, used hydraulic fluids and engine oils), or other containers.

- Many soldiers lack realistic training in field sanitation and many Army units have been observed to operate under substandard hygiene conditions during major field exercises. Inadequate training has been compounded by the environmental protection requirements imposed by Federal and state regulations and by the Army itself. Instead of relying on field expedient waste disposal methods, many troop units during training are required to use portable toilets and to transport their solid wastes to the nearest military installation for disposal. The use of such artificial military training procedures is ultimately reflected in the inability of individual soldiers and units to meet minimum sanitary standards for waste disposal, personal hygiene and mess operations.

  Coupled with the above, is the impression that many field unit commanders are not effectively indoctrinated with respect to adverse impacts of poor field sanitation practices on combat effectiveness. Improved techniques to educate commanders about the Medical Threat to tactical and strategic operations and plans are urgently required.

- In previous combat theaters involving the U.S. Army, it has not been necessary for military units to be concerned with the amounts of water used for personal hygiene and general housekeeping tasks because of adequate water supplies. With the prospects of operation in arid regions, greater emphasis should be given to research and development on water conservation and water reuse. This study has identified a number of ideas for accomplishing this reduction: for example, research on reuse of shower and laundry water, utilization of disposable hygienic wipes and use of non-stick surfaces on cooking equipment and mess kits.

- There is a need to develop better methods to protect field water sources and ensure the safety of soldiers in operations where NBC agents or industrial contaminants may be present. Disposal procedures for NBC contaminated wastes and other hazardous/toxic substances have been addressed, but the guidance provided in Field and Technical Manuals is considered by many Army personnel to be superficial and not particularly helpful to forces required to function in a contaminated environment. This deficiency in doctrine is even more pronounced for similar operations in hot-arid and arctic regions.

A summary of the specific research elements identified in the area of field sanitation is provided in Table 2.

TABLE 2

FIELD SANITATION R&D REQUIREMENTS

PERSONAL HYGIENE

- Evaluate the use of disposable impregnated wipes
- Evaluate the need for skin care lotions in arctic and hot arid climates
- Establish water quality criteria for field laundry and shower operations
- Evaluate operation of laundry and shower units in the arctic
- Evaluate water reuse procedures for laundry and shower units

HUMAN WASTE DISPOSAL

- Evaluate use of disposable impregnated wipes
- Provide guidance which emphasizes the importance of field sanitation procedures during training
- Identify field expedient disposal methods for cold climates and arid regions
- Develop data bank of information on climate, soil and groundwater conditions in different theaters of operation to allow for advanced preventive medicine planning for human waste disposal

FOOD SERVICE OPERATIONS

- Identify field expedient methods for garbage and rubbish disposal in the arctic
- Develop data bank of information on climate, soil and groundwater conditions in potential theaters of operation to allow for advanced preventive medicine planning for food service operations
- Clarify policy on ocean disposal of wastes during wartime
- Develop methods to reduce water requirements for cleaning mess equipment
- Evaluate the need for a field mess sink
- Develop positive disinfecting procedures for mess kits and bulk cooking utensils
- Identify field expedient methods for disposal of mess waste-water in hot, arid and arctic regions
- Provide guidance which emphasizes the importance of good sanitation in the field mess

TABLE 2
(continued)

MEDICAL AND PATHOLOGICAL WASTES

- Provide specific guidance on ocean disposal of pathological and infectious wastes

HAZARDOUS WASTE PRODUCTS

- Identify possible use of waste fuels and engine oils for burnout latrines
- Provide guidance on disposal of pesticides and pesticide containers in theater of operations
- Develop detailed guidance for the field disposal of NBC contaminated wastewaters and decontamination washwater

II. BACKGROUND

A. Purpose and Scope

A considerable amount of work has been conducted by the Medical Research and Development Command (MRDC) in the area of field water supply and field sanitation. However, there is a need to establish an adequate framework for evaluating this work and particularly to identify data gaps and problem areas which fall within the responsibility of the Army Medical Department. The Medical Bioengineering Research and Development Laboratory (MBRDL) has attempted to meet this need, by conducting a problem definition study covering field water supply and field sanitation. The specific objective of the study is to provide an assessment and discussion of the following:

1) current Army practices and capabilities in these two major subject areas

2) potential health effects from present practices or lack of appropriate doctrine (criteria, analytical capabilities and procedures)

3) potential data gaps and research needs

The focus in each topic is on problems associated with field water supply and field sanitation, which may adversely affect health, well being, or combat efficiency of military personnel in the field. We have attempted to identify any areas where additional research and development work would be useful and to pinpoint areas where research and development programs can supply critical data needs.

The process of documentation was approached in two ways. A major emphasis was placed on extensive field interviews with the many Army functional staff and operational units connected with or responsible for water supply and field sanitation. The second approach was to carry out a comprehensive literature evaluation and the compilation of an extensive bibliography of all the relevant data sources. The two sources of information were then combined, organized and evaluated to produce the information provided in this report.

B. Field Interviews

An extensive field interview program was undertaken because it was believed that a large body of real experience existed in various Army establishments pertinent to the needs and objectives of this program. The field interview approach was chosen as the best means to fully establish past practices, present doctrine and future needs in terms of data and/or research program requirements. Particular efforts were made during field interviews to document actual field experience and to retrieve informal written communications which would not be readily accessible through normal search channels. Efforts were also made to seek out those Army personnel most closely connected with the issues and requirements of water supply and field sanitation. A cross section of Army establishments were contacted, covering research and development, training and doctrine, operational units, support units and liaison units. In addition, interviews were held with the Navy, Air Force, Marine Corps, and civilian authorities responsible for dealing with Field Water Supply and Field Sanitation problems.

A critical function of these field interviews was to obtain inputs on research and development needs as perceived by the various military units. With these direct inputs, MBRDL can more thoroughly and objectively evaluate its research programs, prioritize its future research objectives and budget to best meet the "users" needs.

Interviews were prearranged by letter or by telephone and in most cases consisted of one- to two-hour sessions with small groups of key military personnel. Persons conducting the interview were equipped with an interview document which outlined the areas to be covered in order to provide some uniformity to the interview process. Although each document covered the same ground, they were tailored to each of the five functions noted above. Table 3 gives a listing of all the interviews which were made during the course of this study. At the end of the interview, documentation of relevant material obtained from interviewees was prepared and subsequently a memorandum interview report was prepared summarizing the information obtained. These interview reports are included in Appendix A* of this report and information from those interviews is referenced where appropriate in the corresponding topics which make up the body of this report.

In addition, a meeting was held on December 4, 1980, at the Army Environmental Hygiene Agency, Edgewood Area, Aberdeen Proving Ground, MD, to discuss the scope of the project, a tentative approach to the documentation, and to report progress to date. It was attended by 20 Army personnel directly involved in various aspects of field water supply and field sanitation. See Appendix A, 1.9. This meeting provided much interesting discussion and was very helpful in the formulating the scope and direction of the remaining portion of the study. In particular it provided a discussion of the key areas of interest and it identified other key military personnel for inclusion in the field interview program.

C. Literature Review

The literature review included a comprehensive evaluation of in-house background data, published literature, and military literature. To identify pertinent published literature, the seven computerized data bases identified in Table 4 were searched from the date indicated to the present (1980). In addition, various documents were obtained from the World Health Organization, the Agency for International Development (AID), and the World Bank. Each of the computerized data bases was searched using primary key words (identifiers), in most cases coupled with secondary key words (descriptors) which were used to limit the search to a reasonable number of citations and eliminate irrelevant material. An example of the search method and some representative key words used are shown in Table 5.

*See explanatory note b, page 186.

TABLE 3. ESTABLISHMENTS CONTACTED IN FIELD INTERVIEW PROGRAM

I. RESEARCH AND DEVELOPMENT FUNCTIONS

1.1 US Army Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH

1.2 US Army Construction Engineering Research Laboratory (CERL), Champaign, IL

1.3 US Army Chemical Systems Laboratory (CSL), Aberdeen Proving Ground, MD

1.4 US Army Medical Intelligence Information Agency (MIIA), Fort Detrick, MD

1.5 US Army Mobility Equipment R&D Command (MERADCOM), Fort Belvoir, VA

1.6 US Army Natick R&D Command (NARADCOM), Natick, MA (a, b and c)

1.7 US Army Research Institute for Environmental Medicine (ARIEM), Natick, MA

1.8 US Army Engineer, Waterway Experiment Station (WES), Vicksburg, MI

1.9 US Army Medical Bioengineering R&D Laboratory (meeting held at Environmental Health Agency (EHA))

II TRAINING AND DOCTRINE FUNCTIONS

2.1 US Army Academy of Health Sciences (AHS), Fort Sam, Houston, TX

2.2 US Army Engineer School (AES), Ft. Belvoir, VA (a, b and c)

2.3 US Army Environmental Hygiene Agency (EHA), Aberdeen Proving Ground, MD

2.4 US Army Office of Surgeon General (DA-OTSG), Washington, D.C.

2.5 US Army Training and Doctrine Command (TRADOC), Ft. Monroe, VA (doctrine)

2.6 Uniformed Services, University of Health Sciences (USUHS), Bethesda, MD

TABLE 3 (CONTINUED)

III OPERATIONAL FUNCTIONS

3.1 US Army, Europe (REUR)

3.2 US Army 224th Medical Detachment (LB), 1st Medical Group, Ft. Hood, Tx.

3.3 US Army Forces Command (FORSCOM), Ft. McPherson, GA

3.4 US Army XVIII Airborne Corps, Ft. Bragg, N.C.

IV SUPPORT FUNCTIONS

4.1 US Army Health Services Command (HSC), Ft. Sam, Houston, TX

4.2 US Army Office of the Chief of Engineers (OCE), Washington, D.C.

4.3 Defense Pest Management Information Analysis Center (DPMIAC), Bethesda, MD

4.4 US Army Deputy Chief of Staff for Logistics (DSCLOG), Washington, D.C.

4.5 US Army Logistics Center, Fort Lee, VA; (US Army Troop Support Agency) (TSA), Ft. Lee, VA

4.6 US Army Office of the Surgeon General (OTSG), Washington, D.C.

4.7 US Army Engineer Topographic Laboratory (ETL), Terrain Analysis Center (TAC)

V LIAISON FUNCTIONS

5.1 US Agency for International Development (AID), Arlington, VA

5.2 US Marine Corps Air/Ground Combat Center, Twenty-Nine Palms, GA

5.3 US Navy Civil Engineering Laboratory (CEL), Port Hueneme, CA

5.4 US Navy Bureau of Medicine and Surgery, Bethesda, MD

5.5 World Bank, Office for UN Development Program's Global Water and Sanitation Project, Washington, D.C.

TABLE 4

LITERATURE SOURCES EVALUATION

Resources Searched

1)	Defense Technical Information Center (DTIC)	Current
2)	National Technical Information Service (NTIS)	1964-
3)	Engineering Index	1970-
4)	Environmental Abstracts	1970-
5)	Pollution Abstracts	1970-
6)	Excerpta Medica	1974-
7)	IRL Life Sciences	1978-
8)	World Health Organization (WHO) Catalog	1947-1979
9)	NAS Military Advisory Committee, Archives	As Available
10)	Armed Forces Epidemiology Board, Minutes	As Available
11)	Military Intelligence (Unclassified)	As Available
12)	After Action Reports (field exercises and combat)	As Available
13)	Department of Defense (DOD) Manuals (see Table II-4)	Current

TABLE 5

COMPUTER SEARCH KEY WORDS

(Identifers)		(Descriptors)	
Water		Military	Disaster
Potable Water		Army	Contamination
Water Sources	with	Navy	Treatment
Sanitation	and/or	Air Force	Disinfection
Sanitary		Marines	Consumption
Hygiene		Health	Supply
Reuse		Medic	Field
		Disease	Transport
		Epidemic	Reuse

Example of Search Method

Key Words:	Result:
Potable Water/Medic, Health, Disease (Too broad — limiting descriptors added)	200 References
Potable Water/Medic, Health, Disease/Military	10 References

The main source of military information proved to be the DOD manuals for the Army of which 65 were identified as containing relevant information on field water supply and field sanitation. A listing of these manuals is shown in Table 6. Manuals directly pertaining to the two topics were obtained to serve as permanent reference sources. For other documents containing smaller amounts of information, the relevant sections were copied to add to the document file. A search was also carried out of the computerized military intelligence files (unclassified) at Fort Detrick and various after-action reports were obtained during the field interview program. In general, about 40-60% of the documents identified contained material relevant to the study. Useful references have been incorporated into the bibliography which forms Appendix B of this report. It is organized under the subject headings used in the body of the report and is formatted for computerization and retrieval using the USAMBRDL system (ABRRS). All pertinent material used is archived at MBRDL.

D. Methodology

The methodology devised in this study to produce this final report is designed to satisfy two audiences, both of whom were felt to be equally important in terms of disseminating the results of this work. The first audience is the personnel at MBRDL who sponsored the work, and other R&D activities who required a comprehensive documentation of all the information, together with a listing of data gaps and research needs for each subject area. The second audience is the various communities in the military who are directly involved in providing adequate and safe field water supply and field sanitation. For this second audience it is hoped that this report will provide a convenient source document, organized to provide quick access for users in specific subject areas.

The information in each of the two major subject areas has been divided into categories, 6 categories covering field water supply and 5 categories covering field sanitation as described below.

Field Water Supply

A. Water Sources
B. Water Consumption
C. Water Quality (Potable Water)
D. Detection and Analysis of Water Contamination
E. Water Treatment
F. Transportation/Storage/Distribution

Field Sanitation

A. Personal Hygiene
B. Human Waste Disposal
C. Food Service Operations
D. Medical Wastes
E. Waste Products

TABLE 6

DOCTRINE IDENTIFIED IN MILITARY LITERATURE*

I. FIELD WATER SUPPLY

A. WATER CONSUMPTION AND WATER QUALITY

AR # 70-38, 40-5
FM # 31-71, 90-3, 31-35, 31-72, 21-76
TB # QM13, MED 175, MED 288
TM # 10-275, 5-884-2, 5-813-6, 5-813-1, 5-813-7, 8-501, 5-700
DA Cir 40-12

B. WATER SOURCES

AR # 200-1
TM # 5-884-2, 5-813-7, 5-813-3

C. CONTAMINATION

AR # 10-5, 220-58, 420-46, 40-37, 700-52, 40-5, 40-61
FM # 21-40, 21-41, 5-34, 21-10, 21-48, 3-15
TB # MED 229, MED 700-4
TM # 5-311, 5-700, 5-665, 5-666, 8-215, 8-285, 9-2330-213-14
SB # 740-6665-94-19, 3-30-208

D. TREATMENT

AR # 420-46, 40-5, 715-15, 115-20
FM # 21-10
TB # 34-9-140, MED 5, MED 206, MED 229
TM # 5-700, 5-813-3, 5-4610-204-10, 5-4610-204-20P, 5-4610-205-10, 5-4610-202-12, 5-4610-220-14, 5-4610-221-15, 5-4610-224-ESC
A Sub Scd # 5-5IN20

E. TRANSPORTATION, STORAGE AND DISTRIBUTION

AR # 56-9, 115-20
TM # 5-343. 5-661, 5-813-2, 5-813-4, 5-813-5, 10-4520-200-1

II. FIELD SANITATION

AR # 40-5, 200-1, 210-30, 420-46
FM # 21-10
TM # 5-814-1, 5-814-2, 5-814-3, 5-814-5, 5-814-6, 5-852-2, 5-852-5, 5-884-3
TC # 8-3
A Sub Scd # 8-8

*These documents are published by the Department of Defense, Department of the Army. They are listed here by their identification numbers for illustration. A complete reference is provided in the sections of the report where they are appropriately referenced. For availability, see explanatory notes page 185.

Each category is divided into a series of related topics and for each topic the applicable situations are defined.

[Note: Originally the word "scenario" was used in place of "situation", but this term was replaced because it was believed that the word scenario, for Army personnel, implied a much broader and comprehensive description than is intended or is necessary for this prupose.] Each situation is defined by considering the major parameters covering the field conditions. These are:

Operational Environment

1. Local topography/climate (hot arid, tropical, temperate, cold, high altitude)

2. Hostile environmental contaminants (chemical, biological, radiological, opportunity poisons)

3. Industrial or agrarian development

Operational Characteristics

1. Size of force (individual soldier, small units, large units, base camps)

2. Type of force (infantry, artillery, mechanized, rapid deployment forces, specialized units (e.g., medical, engineers))

3. Posture: training, staging operations, offense, disaster assistance operations

In examining the descriptions of relevant situations, it became apparant that field water supply and field sanitation are ultimately directed at the individual soldier. Therefore, the individual requirements under each topic are not equally affected by some of the field parameters mentioned above. To identify the situation in the report, only those descriptors which are important in describing the field situation have been included.

Each topic is described under the following headings:

REQUIREMENTS

Has the doctrine been established? What are the criteria? How effective are the criteria? How effective are the procedures? What is the field experience? What equipment or analytical capability is required?

POTENTIAL HEALTH EFFECTS

What are the potential (known or suspected) health effects on the fighting force or individual soldier from the absence of doctrine, or inadequate doctrine and for inadequate practices in the field? How are the potential health effects described? Loss of efficiency? Temporary incapacity? Casualty? Temporary or chronic effects? How do these effects impact combat or operational efficiency?

DOCUMENTATION

Provides key references from military publications, public literature and field interview reports indexed to the relevant information described under requirements and potential health effects.

DATA GAPS AND RESEARCH NEEDS

As identified in assessment of the published data or from observations made during field interviews. (Summarized in Table 1 and 2)

III. WATER SUPPLY

A. Water Sources

Introduction

The worldwide distribution of water sources is important information for planning water supply for military operations. At present no comprehensive data base exists. Ideally, all known water sources and potential water sources should be tabulated. The location (both geographical and political), quality, technology required to develop the source, and treatment technology to produce potable water should be contained in a data base easily accessible to the U.S. military forces.

Available information on typical water sources and corresponding water quality is grouped by climatic regions (cold, hot, arid, and temperate and tropical). Temperate and tropical are discussed together since sources in both regions share many similar characteristics although water quality problems may differ. Quantative information is lacking but the data is useful in planning personnel and equipment needs for water supply for military operations in these regions.

The following topics are discussed in this section:

- Worldwide Availability of Water Sources for Potential Development to Support Military Operations
- Water Sources in Cold Climates
- Water Sources in Hot, Arid Climates
- Water Sources in Tropical and Temperate Climates

TOPIC 1: Worldwide Availability of Water Sources for Potential Development to Support Military Operations

Situation: *Operational Environment - All*
Operational Characteristics - All

REQUIREMENTS

Criteria:

1) Identify water sources by geographical location and political boundaries.

2) Identify the water quality of sources and the treatment methods necessary to supply water for potable and nonpotable uses.

Information on Water Sources:

1) Statistics of worldwide water resources can be found in Fritz van der Leeden's Water Resources of the World.[1] Information is presented on a country by country basis and includes:

   i) precipitation rates
   ii) water usage rates
   iii) size and location of surface waters
   iv) groundwater presence
   v) quality of water

2) A report, Water Quality of the Soviet Union- A Review,[2] identifies the major surface waters in the country and the corresponding water quality.

3) Groundwater availability in the Middle East is mapped on a scant, moderate, and plentiful basis.[3] A CIA "Issues in the Middle East", 1973 report, is cited as a source of the former information. The Army has some electrical resistivity measuring equipment+ and radar equipment+ which can be used by skilled operators to detect groundwater.[3,4] The electrical measuring equipment is capable of detecting water at depths of 80 feet, and beyond in some geologic formations. Other potential Detection Techniques are identified in Reference 8.

4) Surface water is widespread in cold climates but is often difficult to locate and develop.

Effectiveness:

The information identifies existing sources currently being used. The locations of undeveloped sources, particularly groundwater, are not necessarily completely adequate for application to military operations. The water quality information of the known sources appears sufficient to identify the appropriate treatment technology needed to produce potable water.

+This equipment is not "Standard Military Equipment".

Field Interviews:

1) Work[5] is currently being conducted at the Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, to identify groundwater sources in certain areas of the Middle East.

2) The U.S. Army Engineer Topography Laboratory is mapping water sources in the Middle East. The sources will be identified as existing, surface, and groundwater sources and further classified by water quality characteristics.[6]

3) TAHAL, Engineers, an Israeli[7] consulting company, is a source of information on water supply in hot, arid regions.

POTENTIAL HEALTH EFFECTS

See Section III B. Water Consumption and C. Water Quality.

DOCUMENTATION*

1) Fritz van der Leeden; Water Resources of the World, Selected Statistics, Water Information Center, Inc., Port Washington, New York, 568 pgs, 1975.

2) J.D. LaMothe, et. al.,; "Water Quality of the Soviet Union - A Review", Med. Intelligence Office, Office of the Surgeon General, U.S. Army, Wash., D.C., Departmental Report, July 1971.[f]

3) Gould, P., et al.; "Water Supply and Distribution Equipment for the Rapid Deployment Force (U)", Paper -1487, March 1980, Institute for Defense Analyses, Alexandria, VA.

4) Arcone, S.A., et al.; "Detection of Artic Water Supplies with Geophysical Techniques", Cold Regions Research and Engineering Laboratory, Report 79-15, June 1979, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH.

5) Interview with Personnel at U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, February 27, 1981, (Appendix A, 1.8).[b]

6) Interview with Personnel at U.S. Army Engineer Topography Laboratory, Fort Belvoir, VA, 12 March 1981, (Appendix A, 4.7).[b]

7) Interview with Personnel at MERADCOM, Fort Belvoir, VA, 12 March 1981 (Appendix A, 1.5).[b]

8) Smith, D.W., et al.; "Rapid Detection of Water Sources in Cold Regions, A Selected Bibliography of Potential Techniques", CRREL Special Report 79-10, May 1979, by R&M Consultants, Inc., Anchorage, Alaska for U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, N.H.

*For explanatory notes a-g, see page 186.

DATA GAPS AND RESEARCH NEEDS

1) A comprehensive data base giving the location, type and quality of water source is not yet available. (Waterways Experimental Station (WES) and the Engineer Topographical Labs are developing a data base which may be adaptable to preventative medicine requirements)

2) Information corresponding to the data base cited in (1) on procedures to develop an identified water source and the treatment necessary to produce potable water is not available and should be developed.

3) It is perceived that there is insufficient equipment and skilled personnel to locate groundwater sources in potential military theaters of operation.[5] Ways to correct this deficiency should be investigated.

TOPIC 2: Water Sources in Cold Climates

Situation: *Operational Environment - Cold Climates*
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

Surface water must:

1) meet raw water quality standards in TB MED 229,
2) be amenable to treatment technologies available to the Army,
3) be able to yield required quantities.

Potential Sources:[1,2]

1) Surface water

   a) Lakes and reservoirs are usually shallow, the water is generally of good quality in pristine areas, requiring only disinfection before use. However, high mineral content and organic matter in some shallow sources discolor the water and make it unpalatable.

   b) Rivers and streams are typically small and erratic in flow characteristics. The water is generally turbid with concentrations of sediments over 2000 ppm common in glacial streams.

2) Groundwater

   a) Suprapermafrost groundwater sources are located usually within 10 feet of the surface and receive water from the contaminated zone of the soil. The yield is generally small and erratic.

   b) Intrapermafrost water is of variable quality, low in occurrence, and not an important water source.

   c) Subpermafrost groundwater is generally high in mineral content, stable in yield.

3) Ice and Snow

   Readily available, but difficult to process in sufficient quantity.

4) Seawater

   Only available in some coastal regions. Must be desalinated for potable use.

5) Recycled Water

Not feasible for individual or small field units. Feasible for large units but needs specialized equipment and treatment.

Effectiveness:

1) Many streams and lakes are not reliable for continuous supply of water but are sufficient for short term utilization[3]. Ice and/or solids in shallow rivers and lakes necessitate measures to prevent plugging of water intake points. A direct filtration, pilot treatment plant successfully treated Alaskan River water in 1980[4]. Freezing of a shallow water source is a major problem in the winter. High solids content may reduce the disinfection efficiency of chlorination.

2) Subpermafrost groundwater is a reliable source of water but is high in mineral content, difficult to locate and develop. Detection methods for groundwater are available but require specialized equipment and skilled operators[5,6]. Well drilling requires skilled engineers and heavy equipment. Equipment suitable for use during military operations is not available[7]. The suprapermafrost groundwater is subject to contamination from subsoils and both the supra and intrapermafrost sources are not dependable sources of water.

3) Ice and snow are acceptable sources of small quantities of water in pristine areas, but are subject to contamination in areas of human activity. Ice caps or glaciers can serve as a major source of water. An ice well (Rodriguez Well)[1] is made by using steam to melt a shaft or a well in the ice where water accumulates and is subsequently pumped to a treatment system.

4) Seawater can be utilized but special treatment equipment such as distillation or reverse osmosis treatment units is needed to produce potable water.

5) Reuse of water for non-potable purposes is possible and would reduce the demand on the other available sources. Shower water was reused at Thule Air Base to flush toilets.

6) The raw water quality standards cited in TB MED 229 are of limited value because field units have limited ability to make the necessary measurements.

Field Interviews[7]:

1) Water sources in Alaska are plentiful but inaccessible at many times during the year.

2) Groundwater often contains high levels of minerals and organics for which standard water treatment techniques are not effective. Ozonation is an effective method to break up metal/organic complexes.

3) Well drilling equipment for obtaining groundwater has not been tested during the winter.

4) Contamination of snow with POL products and waste occurs near human activities and is a problem when utilizing snow as a water source.

POTENTIAL HEALTH EFFECTS

1) See Section III C, Water Quality, Topic 2 for health effect of consumption of water with high mineral content.

2) See Section III C, Water Quality, Topic 1, for health effects of pathogens in water in cold climates.

DOCUMENTATION*

1) Alter, A.J.; "Water Supply in Cold Regions," Cold Regions Science and Eng. Monograph III-C5a; CRREL Hanover, NH, 1969, AD 685850.[a]

2) Kolb, C.R., ed.; "Review of Research on Military Problems in Cold Regions," 1964, AD 457733.[a]

3) TM 5-700. "Field Water Supply." July 1967.[f]

4) Ross, M.; "Direct Filtration of Streamborne Glacial Silt on the Kenai River," Report by Trans-Alaska Eng., PO Box 797, Seward, AK, for Cold Regions Research and Engineering Laboratory, Hanover, NH.

5) Arcone, S.A., et al.; "Detection of Arctic Water Supplies with Geophysical Techniques," CRREL Report 79-15, June 1979, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH.

6) Smith, D.W., et al.; "Rapid Detection of Water Sources in Cold Regions A Selected Bibliography of Potential Techniques," CRREL Special Report 79-10, May 1979, by R&M Consultants, Inc., Anchorage, Alaska, for U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, NH.

7) Interview with personnel at U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH., December 18, 1980 (Appendix A, 1.1).[b]

DATA GAPS AND RESEARCH NEEDS

1) The feasibility of developing expedient methods to locate groundwater should be examined.

*For explanatory notes a-g, see page 186.

2) The feasibility of developing an intake device that is not subject to plugging by ice slush or solids from the shallow lakes and rivers should be developed.

3) The feasibility of ice and snow as a suitable short term, expedient water source should be determined.

4) The capability to utilize groundwater and seawater resources in cold climate areas needs to be improved.

5) The capability to treat cold water with high suspended solids content (often found in cold climates) and produce potable water needs further investigation.

TOPIC 3: Water Sources in Hot Arid Climates

Situation: *Operational Environment - Hot, arid climate (deserts)*
Operational Characteristics - All

REQUIREMENTS

Criteria:

Surface water must:

1) meet raw water quality standards in TB MED 229,

2) be amenable to treatment technologies available to the Army,

3) be able to yield required quantities.

Sources:

1) Surface water availability is severely limited. Small ponds are likely to be brackish and high in mineral content.

2) Groundwater is likely to be brackish, particularly water near the surface. Groundwater in high plateau deserts of northern Africa and Australia is very scarce. Groundwater in South American, Asian, and African deserts may be available at depths of hundreds of feet.[1]

3) Seawater is only available in coastal regions. (Seawater from the Gulf of Arabia has a salt content in excess of typical seawater.)

Effectiveness:

1) Availability of surface water is too limited to be dependable as a source and may be contaminated by local use. Information on the general distribution of groundwater is available.[2]

2) Groundwater is difficult to locate and develop and a lot of the groundwater is brackish. Signs of vegetation in a desert environment is often indicative of the presence of groundwater.

3) Seawater needs special treatment and product water may have to be transported long distances.

4) The raw water quality standards cited in TB MED 229 are of limited value because field units cannot make many of the necessary measurements. Alternative methods for field units to evaluate raw quality should be developed.

Field Interviews:

1) Focussing on groundwater will not be a panacea for water supply problems in hot arid climates. Locating and developing a well requires personnel highly skilled in this field, but which are not currently available in the Army. Even with personnel and equipment available, well development can take extended periods of time (up to 2-3 months in some cases).[3,4]

2) Deliberate contamination of surface water by unfriendly forces is considered likely. Available treatment equipment will probably not be sufficient to treat the complete range of possible contaminants. Either ground sources or water transported to the area will be necessary to insure water supply.[5]

POTENTIAL HEALTH EFFECTS

See Section III C, Water Quality, Topics 1 and 2, for health effects of water high in mineral salts, and water containing pathogens from human and animal waste.

DOCUMENTATION*

1) TM 5-700. "Field Water Supply", July 1967.[f]

2) Gould, P., et al.; "Water Supply and Distribution Equipment for the Rapid Deployment Force," March 1980, Inst. for Defense Analysis, Paper P-1487, Alexandria, VA.

3) "Theater of Operations Construction in the Desert. A handbook of Lessons Learned in the Middle East," U.S. Army Corps. of Engineers, January 1981.[f]

4) Interview with Personnel of the U.S. Army Waterways Experimental Station (WES), Vicksburg, Mississippi, February 27, 1981. (Appendix A, 1.8).[b]

5) Interviews with personnel of Uniformed Services University of Health Sciences, Bethesda, MD, March 25, 1981 (Appendix A,2.6)[b]

DATA GAPS AND RESEARCH NEEDS

1) The quantity of groundwater that will need treatment by ROWPU or ERDlator equipment should be determined.

2) Separate standards for potable and non-potable sources should be specified so that in water short areas the available water can be more effectively utilized.

*For explanatory notes a-g, see page 186.

3) Expedient methods to locate and develop groundwater during military operations need to be documented.

4) The Army does not have sufficient trained personnel or equipment necessary to locate and develop groundwater sources for a large field force. Equipment for treatment of salt and brackish waters is particularly deficient.

5) Normal rotary well drilling requires water in substantial quantities as a drilling fluid. Use of foams to augment drilling fluid and reduce water use in arid areas should be investigated.

TOPIC 4: Water Sources in Tropical and Temperate Climates

Situation: Operational Environment - Tropical and Temperate Climates
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

Surface water must:

1) meet raw water quality standards in TB MED 229,

2) be amenable to treatment technologies available to the Army,

3) be able to yield required quantities.

Sources:

1) Surface water is generally available, variable in quality but usually suitable for ERDlator treatment and subsequent use.

2) Availability of groundwater depends on the geology of the location. The quality can range from potable to non-potable with some groundwater containing high inorganic salt concentration (or possibly pathogens).

Effectiveness:

1) Surface water sources in Europe and Vietnam have yielded acceptable quality and quantity of water to support military operations. However, surface water is an accessible military target and susceptible to NBC contamination which would reduce the utility of surface water sources.

2) Groundwater is difficult to locate and develop. Equipment suitable for well drilling during military operations is not available[1]. Groundwater is sometimes high in salt content which damages equipment and can necessitate removal of the salts to obtain potable water quality.

Field Experience:[2]

In Vietnam surface waters contained within secure areas were utilized but in many situations none was available within the secure area. Groundwater was utilized in these instances. Seven Army well drilling teams were assigned in Vietnam to develop groundwater. The teams lacked experience and qualifications and civilian contractor advisors had to be hired to work with the teams. The developed wells were utilized as primary water sources in base camps.

POTENTIAL HEALTH EFFECTS

See Section III C, Water Quality, Topics 2, 3, 4 for potential health effects of pathogens, environmental contaminants and NBC agents in water, respectively.

DOCUMENTATION*

1) Rudavsky, A.B.; "Groundwater Utilization: Study of Methods, with Engineering Analysis (u), (Interim Technical Report)" AD 858430L,[a] 42 pgs., 1969.

2) Benefield, R.O., LTC: "Water Supply in the Republic of Vietnam," AD 825260,[a] 118 pgs., 1967.

DATA GAPS AND RESEARCH NEEDS

1) The feasibility of locating and developing groundwater in a mobile tactical situation, where NBC agents are known to have been used should be investigated.

2) An expedient method to locate and develop groundwater needs to be developed.

3) The training for well-drilling teams should be improved based on the Vietnam experience.[2]

*For explanatory notes a-g, see page 186.

B. WATER CONSUMPTION

Introduction

Required water consumption to prevent dehydration varies with the climate and level of physical activity. A hot climate places extra demand on the body for heat dissipation by sweating and the water lost must be replaced within a short period of time, otherwise both physical and mental performance deteriorate. Cold climate or high altitude conditions may also require higher consumption to prevent dehydration because additional water is lost during normal respiration. Even in temperate climates, dehydration can occur at the extremes of the seasonal variations.

This section contains estimates of current water requirements including experimental data and information on U.S. Army doctrine, and information on doctrine of armed forces from other nations. It addresses the individual water consumption requirements for three climate situations:

- Hot Climate (desert or tropical)
- Cold Climate (arctic or high terrestrial)
- Temperate Climate

Topic 4 also briefly addresses Army needs for potable and non-potable water for other uses which are in addition to individual consumption requirements.

TOPIC 1: Individual Drinking Water Consumption in a Hot (Arid or Tropical) Climate

Situation: *Operational Environment - Hot, Arid or Tropical Climate*
Operational Characteristics - Individual Soldier

REQUIREMENTS

General:

Adequate water intake must be maintained to prevent dehydration and/or heat stroke. It may be roughly defined as water sufficient to replace water lost through excreta, exhaled water vapor and sweat. Sweating is the principal loss mechanism and is necessitated by the physiological requirement to maintain body temperature within a narrow range and to prevent behavioral changes. At high ambient temperatures, sweating is the only efficient physiological mechanism to remove heat.

Criteria:

TB MED 507[1] presents a guide to individual water requirements for drinking purposes in hot climates (See Table 7). They vary from 5 quarts/day for a soldier doing light activity at less than 80°C to 13 quarts/day for a soldier doing strenuous activity at over 80°F. The above doctrine understates the water needs under extreme desert conditions and sustained combat where long range patrols may require 16-20 quarts/day per person.[2] (Allowing for personal cooling and washing increases the above requirement to about 24 quarts/day.[3])

For planning purposes, a figure of 16 quarts/day per person is recommended as an average for drinking water requirements for larger units[4] (excluding wastage, personal cooling, hygiene, etc.).

Under extreme conditions, it is necessary to limit activity in addition to enhancing water consumption. Guidance on appropriate water intake work/rest cycles during field operations for unacclimatized troops is given in TB MED 507[1]. Suggested doctrine for fully acclimated troops[5] is reproduced in Table 8.

TB MED 507 describes how the environment can be evaluated to determine the heat stress and water requirements, using the wet bulb globe thermometer (WBGT) apparatus. The WBGT index takes into account absolute temperature, humidity, air movement, and radiant heat, factors which determine the overall ability of the body to lose heat by various mechanisms. The wet bulb reading is weighted heavily, indicating the importance of evaporative heat loss to remove body heat. An alternative and more compact piece of equipment favored by ARIEM is the "Botsball" (or Botsford Ball) apparatus which gives roughly the same readings as the WBGT apparatus.

TABLE 7

WATER REQUIREMENTS IN HOT ENVIRONMENTS
(from TB MED 507)

Activity	Illustrative Duties	Quarts per man per day for drinking purposes (a guide for planning only) WBGT or WD Index *	
		Less than 80°	Greater than 80°
Light	Desk	5	10
Moderate	Route March	7	11
Heavy	Forced Marches; stevedoring; entrenching or route marches with heavy loads or in NBC protective clothing.	9	13

*80° WBGT or WD index is approximately equivalent to a dry bulb temperature of 85° in a jungle or 105° in a desert environment. (WD = 0.85 WB + 0.15 DB).

TABLE 8

SUGGESTED HOT WEATHER DOCTRINE FOR FULLY ACCLIMATIZED AND FIT TROOPS

1. Water: Drink 1 quart of water in the morning, 1 quart at each of 3 meals, and 1 quart before any sustained activity (dehydration). Frequent drinks are more effective than a single intake of the same amount of water (Men above average size need more water).

2. Water intake, work/rest cycles during field operations.

Heat Condition	Botsball WGT(°F)*	Water Intake (qt/hr)	Work/Rest Cycles (min)
green	80° - 83°	0.5 to 1.0	50/10
yellow	83° - 86°	1.0 to 1.5	45/15
red	86° - 88°	1.5 to 2.0	30/30
black	88° & above	2.0	20/40**

* To convert WGT to WBGT add 2°F. Below WGT of 80°: 50/10 work rest cycles, and drink up to 0.5 qt/hr.

** Depending on condition of the troops.

Source: Reference 6.

Effectiveness:

The signs and symptoms of dehydration and impending heat exhaustion are readily observable and are discussed in TB MED 507. ARIEM believes that following simple rules and guidelines similar to the Israeli Defense Force "Current Heat Doctrine Changes"[7] (see Table 9) can effectively avoid heat exhaustion.

The various estimates of water requirements for individual consumption should provide an adequate allowance for personal consumption based on the field experience discussed below and extensive investigations carried out by Adolf, et al.[8]

Above some level of water allowance, usage is relatively elastic. Conservation measures (not to be misunderstood as reduced ingestion) and the conditions contributing to heat stress can often be significantly altered to reduce overall demand in order to insure that adequate water remains available for drinking to prevent dehydration. The minimum average water requirement for hot climates appears to be 3-4 gals/man/day to be used exclusively for drinking and individual food preparation.

The effectiveness of the water consumption requirements is not determined merely by the availability of water in volume. Adequate ingestion must be maintained through various means: (1) command discipline - require prehydration, insure adequate rest prior to extended periods of activity, and maintain consistent periodic dehydration during rest periods; (2) adequate rest periods while working - allow time for drinking, refilling canteens, dissipation of heat; (3) maximize palatability (see Water Quality, Topic 4).

Field Experience:

A number of reports have recounted the consequences of inadequate water consumption when operating in a hot environment.[7,8,9,10,11] In brief, these reports describe rapid decline of morale and performance and appalling numbers of casualties if water is not consumed.

The Israeli success in the 1967 and 1973 wars apparently resulted in part from a greater recognition of the necessity for adequate fluid intake to combat heat casualties. Hubbard[7] in comparing U.S. and IDF doctrine indicates that the Israeli doctrine reflects an understanding of the physiology of water balance and heat, especially, (1) inadequacy of thirst alone to prevent dehydration, (2) the requirement for mandatory drinking water consumption to replace water lost through sweat, (3) the necessity to adjust physical exertion according to hour of day, season, and ability of the soldier. "It is necessary to drink 11-18 liters/day in the desert." "Drinking is done hourly, and in extreme heat every 30 minutes."

Interviews with personnel at the Marine Corps Air/Ground Combat Training Center,[14] confirmed that they have adopted the policy of forced water consumption during summer exercises. During the summer of 1980, the 4th Medical Battalion supervised summer exercise. There were no heat casualties

TABLE 9

CURRENT HEAT DOCTRINE CHANGES

Provisions of Fluids to be Drunk

1. Consumption of alcohol is forbidden.

2. Thirst is not a reliable indicator of dehydration and soldiers have to be taught to over-drink. (Drinking governed by thirst in the desert produced only 250-500 cc/day of urine).

3. It is necessary to drink 11-18 l/day in the desert.

4. Water is cooled to 13-15°C (58-60°F) by running through iced coils of tubing. Water containers are covered with wet blankets.

5. Chlorinated water is sweetened with sugar. Fruit flavored syrups were preferred and since they increase the sense of thirst, they also increase the desire to drink more.

6. The drinking of carbonated beverages is discouraged because the carbon dioxide creates a feeling of full stomach and discourages further drinking.

7. Drinking is done hourly and in extreme heat every 30 minutes.

8. Mid day urine checks are a routine color test for concentration (Commanders may check white shorts).

Source: Israeli Defense Force (cited by Hubbard[7]) compared to 50 in a comparable exercise the previous summer. The soldiers were consuming, on average, 5-7 gallons a day. Because there was no water shortage, a significant amount was being used externally to cool the body, particularly the head.

Adolf, et al.,[8] and Sohar, et al.,[15] conducted experiments using young, healthy men of military age who performed a wide variety of activities in a desert climate, with and without water. The findings and conclusions of these studies can hardly be improved upon today.

POTENTIAL HEALTH EFFECTS

The signs, symptoms, pathophysiology, prevention and treatment of inadequate fluid intake in relation to heat stress are described in great detail by Adolf, et al.[8] and more succinctly in TB MED 507[1]. In brief, the major physiological problem associated with human activity in any hot environment is the need to maintain body temperature within a narrow range, which becomes more difficult at high ambient temperature. Decreasing muscular activity curtails heat production. Cooling the body is accomplished primarily by evaporation of sweat. Convection and radiant cooling are minimal at ambient temperatures (50-90°F) and are positive gains of heat to the body when ambient temperature is above body temperature.

The quantity of water lost by sweating has been determined to be as much as 1.5 quarts per hour during physical exertion at high ambient temperatures. This water loss can be seen as a decrease in body weight occurring over short periods of time. Loss of 2.5% of body weight (2 quarts) as sweat is reported to be associated with a 25% decrease in efficiency[12]. Water loss equivalent to 6% of body weight results in complete incapacitation of humans[10]. Only if the water loss by sweat is adequately replenished can man function and survive in the desert.

Heat injury is described by a standard medical text[13] in three levels: heat syncope, heat exhaustion, and heat stroke. Heat syncope is a minor medical problem associated with low blood pressure resulting from excessive cutaneous vascodilation. The obvious symptom is fainting with rapid recovery in the recumbent position. Treatment is rest and fluid ingestion. Heat exhaustion is the result of more prolonged fluid depletion. In this case, there may also be a deficiency of sodium chloride resulting from loss by sweat. Symptoms are thirst, fatigue, giddiness, elevated body temperature, oliguria and delirium. It is suggested that the condition of heat exhaustion can be prevented by adequate replacement of water lost as sweat.

Heat stroke, by contrast to the two preceding conditions, is a medical emergency associated with failure of the heat regulatory mechanisms to maintain the core body temperature below a critical level (104°F). Death may result from the central nervous system's inability to regulate circulatory homeostatic mechanisms at the elevated temperature. Inadequate water intake is associated with the pathogenesis of this state.

In preventing these three forms of heat injury, adequate water intake is required coupled with limits on heavy physical activity to prevent excessive heat production.

Acclimatization:

Acclimatization to heat is a physiological process which allows more efficient use of heat loss mechanisms. It usually develops fully after 2 or 3 weeks of exposure to heat stress. Heat stress should not be construed to mean mere exposure to heat; heat stress depends on the overall demand on the body to eliminate heat, which is a function of internal heat generation due to physical activity and external temperature. Acclimatization does not decrease the need for water ingestion, rather it increases the work ability of well-hydrated individuals. The acclimatized individual sweats sooner and the sweat is more dilute or lower in electrolytes. Thus, there is more retention of sodium and chloride in the acclimatized individuals.

There is practically no risk of overingestion of water. Deficiency of sodium (Hyponatremia) may occur in unacclimatized individuals as a result of sodium lost in sweat and urine. It is usually replaced in the normal diet, without the need for additional salt consumption. Dehydration accompanied by excessive salt consumption may result in Hypernatemia, therefore increased salt consumption must be prescribed and supervised by medical personnel and not left to the individual. Acclimatized individuals retain more salt while sweating and should not need additional salt. Therefore, sweating should be limiting until the individual becomes acclimatized.

DOCUMENTATION*

1. TB MED 507. The Etiology, Prevention, Diagnosis and Treatment of Adverse Effects of Heat. July 1980. (Supercedes TB MED 175).[f]

2. Dangerfield, H.C. Letter to HQDA (DASG-PSP/Col. Stebbing). Drinking Water Requirements for Hot Environments, SGRD-VEZ, 17 July, 1980.[e]

3. Goldman, R.F. Letter to Col. Herwig, DASG: SGRD-UE-ME, July 21, 1980.[e]

4. Telex from CDP, UAWLOGC, Fort Lee, VA. Multi-Service Water Consumption Planning Factors, November, 1980.[e]

5. Heat Circular (addition to TB MED 507) Provisional Doctrine for Water Consumption and Levels of Activity in Hot Environments, issued by USARIEM, Natick, Mass., March 31, 1981.[e]

6. Beshir, M.Y. A Comprehensive Comparison between WBGT and Botsball, American Industrial Hygiene Association Journal. 42:81, 1981.

7. Hubbard, R.W. "An Analysis of Current Doctrine in use (USA vs. IDF) for the Prevention and Treatment of Heat Casualties Resulting from Operations in the Heat." Prepared for Commanding Officer's Conference, 4th MAW/MARTC, New Orleans, LA, 2-4 October, 1978.[e]

8. Adolf, E.F., et al. Physiology of Man in the Desert. Interscience Publishers, Inc., New York. 1947.

9. Hubbard, R.W. "Water as a Tactical Weapon." Report to the Commander, USARIEM, 9 September 1980.[e]

10. ATCL-CFT. Letter of Instruction on Water Distribution in a Desert Environment. Six enclosures, undated from the Department of the Army, U.S. Army Logistics Center, Fort Lee, Virginia.[e]

11. Impact of Heat on Fighting Forces. Undated, source unknown.[e]

12. Pond, A. "A Foot in the Desert." USAF Environmental Information Division, Publication D-100, 1951.[e]

13. Beeson, P.B. and W. McDermott, eds. Textbook of Medicine. 14th ed. W.B. Saunders Company, Philadelphia, 1975. pp. 64-66, 1581-1585.

14. Interview with Personnel at the U.S. Marine Air/Ground Combat Training Center, Twenty Nine Palms, CA. January 28, 1981 (Appendix A, 5.2)[a]

15. Sohar, E., Kaly, J. and Adar, R. The Prevention of Voluntary Dehydration Environmental Physiology and Psychology in Arid Conditions (B205).[e]

*For explanatory notes a-g, see page 186.

16. Kuhns. Assessment of Water Requirements and Capabilities of the RDF, DAEN-ZCM, April 2, 1980.[e]

17. STANAG 2885. Proceedings for the Treatment, Acceptability and Provision of Potable Water in the Field.[e]

18. Petree, N.C. Water Action Plan Tasking, ATCL-CW, October 10, 1980.[e]

19. TM 5-700. Field Water Supply, July 1967.[f]

20 Crowdy, J.P., Col. RAMC. Drinking Water Requirements in Hot Countries. Army Personnel Research Establishment Report, January 1968.[e]

DATA GAPS AND RESEARCH NEEDS

1. Drinking water requirements in hot environments are amply documented, but there is a need to establish the margin of safety in these allotments as a function of timeliness of water provision, anticipation of relative shortages and training of all personnel in the prioritization of water usage.

2. Better information on wastage factors and requirements for different types of force under different activities should be obtained.

3. The most convenient "Temperature" index to provide quick estimation or water needs to field commanders should be defined and adopted.

4. Data are needed for field commanders or health personnel to evaluate the risk from consumption of poor quality or contaminated water versus the risk of dehydration.

5. Methods for small mobile combat units to meet their water needs are not documented.

6. Under combat conditions, water consumption may be irregular: the effect of irregular consumption and efficiency should be evaluated.

7. Additional requirements for individuals in NBC protective clothing should be documented.

(Questions of water quality are discussed in the following Section C, Water Quality)

Topic 2: Water Consumption in Cold, Arctic or High Altitude Environment

Situation: *Operational Environment - Arctic or High Altitude Climate*
Operational Characteristics - Individual Soldier

REQUIREMENTS

Criteria:

There are no guidelines or requirements for individual consumption of water in either arctic or high altitude environments.

Field Experience:

According to Army medical personnel, dehydration is a common problem for men operating in a very cold environment. The sensation of thirst is not an adequate stimulus to drink water in a cold climate. The drinking of tea and coffee can exacerbate the dehydration, since the zanthines (e.g., caffeine and theophyline) are mild diuretics[1,2]. Alcohol also is a mild diuretic, although the principal hazard associated with its use is vasodilation (more blood circulating to skin and stomach), which leads to more rapid loss of heat[2].

It has been stressed by Army medical personnel that soldiers must be urged to drink water: prehydrate in the morning (up to 1 quart) and drink frequently during the day (1-2 gal/day). Commanders in the field should readily be able to detect dehydration from the color of the urine in the snow which is very commonplace around a camp. Men do not want to walk far to urinate. Orange to dark yellow is indicative of dehydration.

TB MED 288[3] very briefly mentions problems of fluid balance at high altitudes. Increased ventilation to compensate for lower oxygen concentration increases water loss via expired air. More important, the sense of thirst may be blunted at very high elevations. The bulletin stresses that, unless a conscious effort is made to imbibe fluids even in the absence of the sensation of thirst, dehydration becomes a very serious threat.

POTENTIAL HEALTH EFFECTS

Dehydration both in the arctic and at high altitude can represent a serious problem, although one which develops more slowly than in the hot environment of the desert or tropics.

Water is lost through intermittent sweating associated with physical activity. There will be enhanced water loss resulting from respiration because air enters the body with a very low relative humidity and temperature and is expired fully saturated (at 37°C). At high altitude, where hyperventilation is a common phenomenon, this water loss is accentuated[3], and contributes to dehydration injuries. The early symptoms of dehydration are non-specific, including nausea and weakness. The first system to be seriously affected by dehydration is the circulatory system, and it is the combination of compromised circulatory efficiency and cold exposure which results in the common cold injuries of frostbite, trench foot and hypothermia[4].

An acute symptom may develop following sudden change to high altitudes, in which there is increased fluid retention (apparently due to alteration of kidney functions) which is relieved by the diuretic furosemide.[5] The signs and symptoms of acute mountain sickness are discussed in TB MED 288.

DOCUMENTATION*

1. Interview with Personnel of U.S. Army Research Institute for Environmental Medicine, Natick, Mass., December 8, 1980. (Appendix A, 1.7)[b]

2. Goodman, L.C. and A. Gilman, eds. The Pharmacological Basis of Therapeutics, 4th ed. The MacMillan Company, New York, 1970. pp. 139-140. 362.

3. TB MED 288. Medical Problems of Man at High Terrestrial Elevations, October 1975.[f]

4. AR 40-5. Health and Environment, September, 1974.[f]

5. Beeson, P.B. and W. McDermott. Textbook of Medicine, 14th ed. W.B. Saunders Company, Philadelphia, 1975. pp. 78-80.

DATA GAPS AND RESEARCH NEEDS

1. There is a lack of appreciation for the need to drink additional fluids in a cold and/or high-terrestrial environment. Data should be developed to provide adequate consumption factors as a function of temperature, humidity, altitude, physical activity, acclimatization, etc.

2. Quantitative data on relative rates of dehydration in cold climates is lacking. It should be obtained and correlated with decrements in individual performance.

3. The additional and possibly different requirements for individuals wearing NBC protective clothing should be separately investigated.

*For explanatory notes a-g, see page 186

TOPIC 3: Water Consumption in a Temperate Climate

Situation: *Operational Environment - Temperate Climate*
Operational Characteristics - Individual Soldier

REQUIREMENTS

Criteria:

TM 5-700 specifies water consumption for temperate/cold climate conditions[1] as follows:

Field/Combat	Gal per person per day Temperate cold/climate	Remarks
In combat:		
Minimum	1/2 - 1	For eating and drinking only, periods not to exceed 3 days.
Normal	2 3	When field rations are used. Drinking plus small amount for cooking of personal hygiene.
March or bivouac.......	2	Minimum for all purposes.
Temporary camp.........	5	Desirable for all purposes (does not include bathing).
Temporary camp with bathing facilities.....	15	Includes allowance for water-borne sewage system.
Semipermanent camp	30-60	

Effectiveness:

These water consumption estimates appear to provide sufficient margin for drinking water under average temperate conditions (but not necessarily under cold conditions).

A special consideration for the temperate climate is the extremely wide variation in actual environmental conditions with season, which can range from desert-like or semi-tropical to nearly arctic conditions. Those conditions approaching climatic extremes must be allotted increased water for drinking (see Topics 1 and 2 this section).

POTENTIAL HEALTH EFFECTS

The health effects depend on the actual environmental conditions encountered. The consequences of an inadequate water supply under hot or cold conditions are discussed earlier. Problems associated with non-acclimatized troops must also be considered if troops are to be deployed from winter conditions (e.g., northern hemisphere) to summer conditions (southern hemisphere). Acclimatization requires about 2 weeks and only lasts about 2 weeks after soldiers are removed from a hot climate. The experience and training carried out in hot environments will, of course, better prepare command personnel and the individual soldier to avoid heat casualties, but will not eliminate the need to acclimatize when sudden change to a hot climate is made.[2]

DOCUMENTATION *

1. **TM 5-700, "Field Water Supply"**, July 1967.[f]

2. Interview with personnel of U.S. Marine Corps, Air/Ground Combat Training Center, Twenty Nine Palms, California. Jan. 28, 1981 (Appendix A, 5.2).[b]

DATA GAPS AND RESEARCH NEEDS

1. Voluntary dehydration can result from stress and/or physical exertion, even in temperate climates where water is available. The effect of such dehydration on performance should be investigated.

2. Additional requirements to prevent dehydration of personnel who are wearing NBC protective clothing should be determined.

*For explanatory notes a-g, see page 186.

TOPIC 4: Field Water Use (except individual consumption)

Situation: Operational Environment - All Climate/Topography
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

General requirements for water (potable and non-potable) are documented in references 1, 2. Requirements for field hospitals are developed in more detail in references 3, 4. Requirements for RDF operation have been discussed in several documents[5,6] culminating in the water consumption planning factors shown in Table 10.

Decontamination from NBC agents[8] requires 13 gallons for personnel decontamination and 200 gallons per vehicle or major equipment item for equipment decontamination.

Effectiveness:

1) Total water purification capability of engineer units in the RDF is 2.25 million gal/day. Assuming an 80% availability rate, the capability using fresh water sources is 1.8 million gal/day.[6]

2) Equipment is not available in quantity to utilize the salt or brackish water sources typically found in desert areas to obtain large quantities of potable water. (The equipment may be suitable for producing non-potable water for some of the above purposes.)

3) Distribution equipment is not available in quantity to supply units from a central water point.

POTENTIAL HEALTH EFFECTS

Uses and quality of non-potable water are important to the extent that individuals are exposed, e.g., in shower and laundry. Requirements and criteria for non-potable water are not part of established doctrine (see Section III C, Water Quality, Topic 5).

TABLE 10

OTHER WATER SUPPLY NEEDS FOR RDF[7]

		gal/day/person
Potable:	Personal Hygiene	2.7
	Food Preparation	3.0
	Medical (65 gal/day/bed)	1.0
	Heat Treatment	1.0
	Subtotal[a]	7.7
NonPotable;	Showers	1.3
	Vehicles[b]	0.3
	Laundry	2.0
	Construction	1.5
	Graves Registration (50 gal/KIA)	0.2
	Aircraft Maintenance[c]	0.2
	Subtotal[d]	5.5
	Total	13.2

Notes:

a. An additional 4 gal/day/person is used for individual consumption in food and drink.

b. Higher values are assumed by the other services: 0.7, 2.5, 5.2 gal/day/person for the Marines, Air Force, and Navy respectively.

c. Does not include any allowance for NBC decontamination.

d. Does not include any allowance for losses assumed to be 10% in Reference 1.

DOCUMENTATION *

1) TM5-700, "Field Water Supply", July 1967.[f]

2) FM 29-147. Supply and Service Company Direct Support, March 1970.[f]

3) Carter, W.A. "Water Requirements Planning Factors for AMEDD Units Other than Hospitals", HSA-COM, 3 September 1975.[e]

4) Blakmore, V.A. "Evacuation Hospital 400 Bed; Bath, Laundry, Water and Related Equipment Requirements," 30 January 1976.[e]

5) "Letter of Instruction on Water Distribution in a Desert Environment", six encl., from the Depart. of the Army, U.S. Army Logistics Center, Fort Lee, VA, 23801.

6) Hughes, B.C. "Assessment of Water Requirements and Capabilities of the RDF, DAEN PENTAGON, 2 April 1980.[e]

7) TRADOC PAMPHLET 525-11, U.S. Army Operational Concepts, "Near Term Water Resources Management", June 15, 1981.[e]

8) Phillips, W.A. "Water Action Plan taskings," ATZN-CM-CDC, 6 October 1980.[e]

DATA GAPS AND RESEARCH NEEDS

1) The shortfall of equipment available to the U.S. Army for producing the necessary potable water from saline water supplies should be determined.

2) The need and requirements for provision of two water supplies, potable and non-potable, should be investigated.

3) Need to determine if reuse of water will achieve these water needs.

4) The feasibility of using salt or brackish water for shower or laundry purposes should be considered.

5) Criteria for non-potable water should be developed.

*For explanatory notes a-g, see page 186.

C. WATER QUALITY

Introduction

This chapter addresses the adequacy of current and anticipated water quality criteria for field use. Untreated water (raw water) available in the field may contain a wide range of constituents, some natural, some man-made. Typically, raw water must be treated to make it potable. Not insignificantly, drinking water and water used for cooking must also be sufficiently palatable (i.e., have a pleasing taste) so it will be consumed. Water for non-potable applications may also need treatment, but to a lesser degree.

Water quality is discussed under five topics:

Water-borne pathogens
Environmental pollution/opportunity poisons
NBC contamination
Palatability
Recycled water

It is apparent that the difficulties in assessing water quality standards are: first, describing the toxicity of the potentially dangerous constituents, second, determining the maximum tolerable levels and third, estimating the dose based upon consumption (or water concentrations) associated with these levels.

TOPIC 1: Water-borne Pathogens and Effectiveness of Disinfection Procedures

Situation: *Operational Environment - All locations*
Operational Characteristics - All field units

REQUIREMENTS

General:

Potable water must not contain any substances that would cause adverse physiological effects. It should not contain any substances that would cause water to be unpalatable such that a non-potable source might be substituted by the user[1].

Criteria:

Biological criteria for potable field water supplies are set forth in Appendix G of TB MED 229, which specifies that bacteriological contamination should not exceed 1 organism/100 ml, using the membrane filter technique for testing the presence of coliform organisms (Water Testing Kit NSN 6665-00-682-4765).

Surveillance:

Pathogenic organisms are difficult to detect under field conditions without laboratory facilities. Therefore, surveillance of field water supplies is normally limited to frequent testing, sufficient to insure that the required residuals of chlorine are maintained. Bacteriological analyses for field water supplies are conducted as needed by responsible medical personnel[1]. Table 2 of TB MED 229 specifies the minimum required free available chlorine (FAC) residuals in water treated by mobile units. There is a requirement for a minimum of 10 mg/l FAC and frequent measurement of pH in areas requiring viricidal or cysticidal treatment. It is recommended that cysticidal dosages be required, but higher or lower concentrations may be prescribed by the medical authority, based on his knowledge of endemic diseases and other local environmental conditions[1]. TM 5-700 specifies lower FAC's than TB MED 229, and on the basis of published data[5,6,7] these FAC's do not provide much, if any, safety margin. TB MED 229 justifiably notes that "pH control must be exercised to maintain FAC residual within a reasonable range" when the pH is ≥ 9.

Alternative disinfection: Iodine tablets (Globuline), see section on Water Treatment, procedures for use (E-2).

Effectiveness:

(See also Water Treatment)

Chlorination at the levels specified in TB MED 229 is generally effective against bacteria, viruses and cysts. However, a number of factors determine the rate and extent of disinifection - specifically, chlorine concentration, pH, temperature and chlorine demand of the raw water, factors which are discussed in TB MED 229 and TM 5-700.

The ability of a given quantity of chlorine to disinfect water can vary by several orders of magnitude, depending on the conditions and quality of the raw water.

Figure 1 adapted from Reference 3 depicts the approximate conditions of temperature, at a free residual chloride level of 11 ppm and pH required for destruction of cysts of Entameba histolytica. Ammonia, organics and a large number of other impurities in raw water may react with added chlorine to inhibit the disinfection process. These impurities constitute the chlorine demand on the water. This demand is met by adding additional chlorine. Further discussion and detailed procedures for testing and obtaining the free residual chlorine specifications are put forward in TB MED 229, Appendix C[1], TM 5-700[2] and FM 21-10[4]. (Additional useful information is contained in references 18 and 19).

Based on published experimental data[5,6,7], two related problems are identified. Guidelines for FAC residuals[1] provide a margin of safety under more or less typical conditions of temperature (>20°C) and pH (<8), but the margin of safety is reduced at low temperature and high pH. For example, data from Snow[3] indicate that 11 ppm FAC at 5°C, pH 7.8 is not cysticidal after 30 minutes' contact time. It should not be presumed that all parasitic organisms exhibit similar sensitivities to chlorine, as does E. histolytica. For example, the non-pathogenic nematodes Diplogaster nudicapitatus and Cheilobus quadrilabiatus showed greater than 70% survival after 1 hour's contact time at FAC residuals of 12.7 ppm at pH 6.7 - 7.2 and 25°C. Certain forms of Giardia Lambia are also resistant to chlorination, especially at low temperatures. Water in unpopulated areas may be contaminated with giardia organisms derived from the wild animal population[20]. Filtration appears to be effective for removing these and similar organisms[21].

Studies conducted at Harvard University in the 1940's[8,9] demonstrated that iodine at 5-10 ppm was effective in 10-20 minutes against bacteria and E. histolytica cysts at pH 7 and temperatures near 0°C. I_2 is not as easily hydrolyzed to HOI as is CL_2 to HOCl, and therefore iodine disinfection is stated to be less dependent on pH. (See Water Treatment, Section III E, Topic 2).

Field Experience:

Water treatment with respect to removal of water-borne pathogens has generally been effective. However, there is little documented military epidemiological data to support or refute this view, due to the difficulty in determining the etiological cause of small outbreaks or individual cases of disease. Lack of effectiveness is usually attributed to absence of disinfection or contamination during distribution, e.g.:

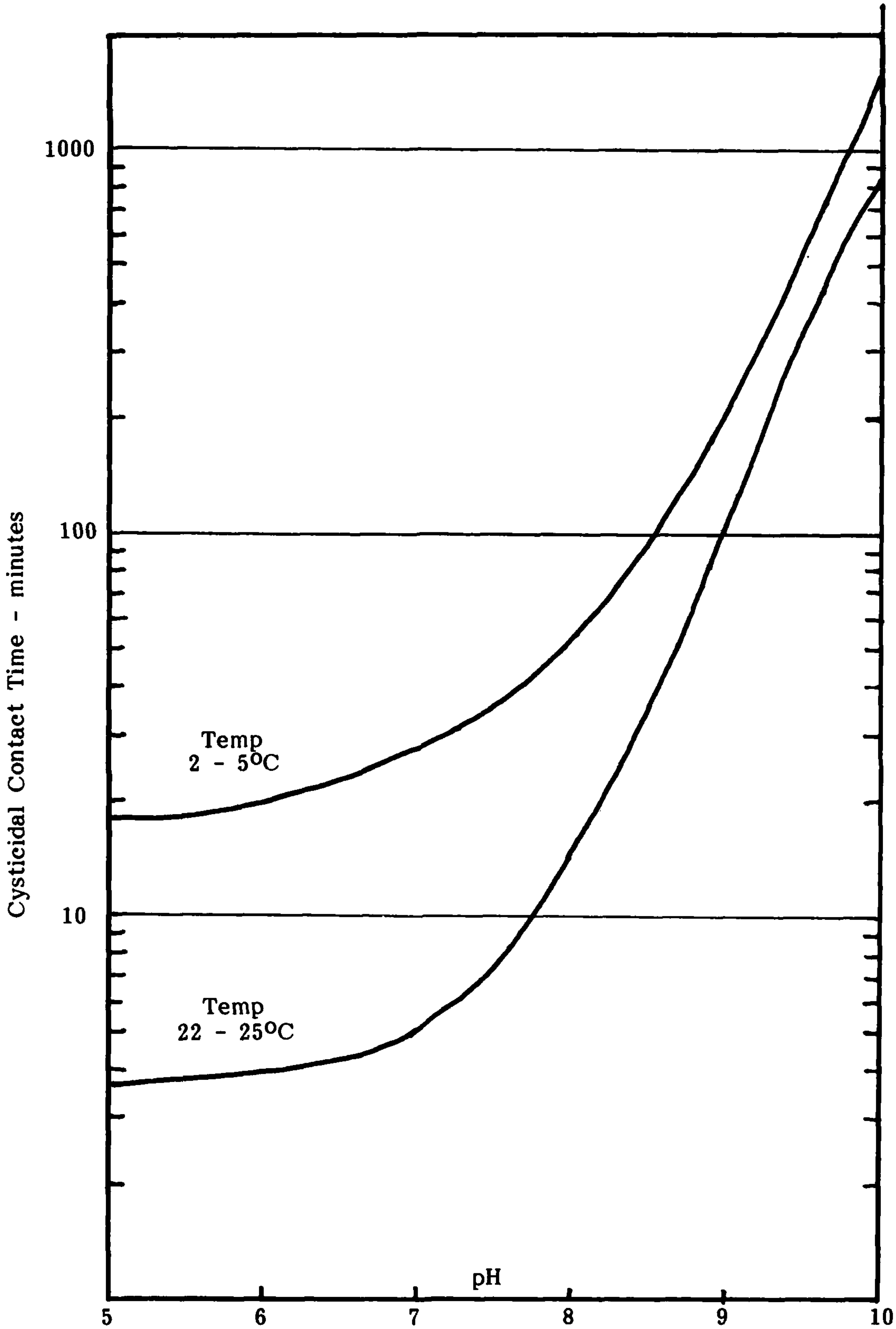

FIGURE 1. MINIMUM CONTACT TIME FOR THE DESTRUCTION OF CYSTS BY CHLORINE DISINFECTION (At a residual chlorine concentration of 11 ppm)

Source: Derived from Reference 3.

- soldiers in Vietnam drinking beverages cooled with contaminated ice or eating contaminated food;

- in Europe, use of a non-potable water source, for drinking water although adequately marked as non-potable.

- failure to use iodine disinfection due to a soldier's preoccupation with other concerns while on patrol.

Craun, et al.,[10] and Hughes, et al.,[11] have discussed the outbreaks of waterborne diseases in the United States between 1971 and 1974. Over 50% of reported cases were attributed to use of untreated ground or surface water, and about 44% were attributed to treatment deficiencies - usually inadequate or interrupted chlorination and failure to use filtration to remove giardia cysts. It should be noted here that lower residual chlorine levels are generally acceptable for most water supplies in the United States than is specified in TB MED 229. Cysts may survive a simple water treatment process such as of chlorination to 1 ppm. The principal causes of disease, in order of prevalence, were[10, 11] giardiasis (30%), shigellosis (16%), chemical poisoning (3%), hepatitis A (2%), typhoid (1.3%), salmonellosis (0.2%). About 47% of cases could not be etiologically identified and were classified as gastroenteritis.

POTENTIAL HEALTH EFFECTS

TB MED 229[1] lists 5 principal diseases contracted by man from ingesting contaminated water: cholera, typhoid fever, amebiasis, shigellosis and infectious hepatitis. These and a number of other diseases which are potentially transmittable in an adequately treated water supply are listed in Table 11 along with a brief description of the effects, the geographic distribution and the effectiveness of chlorination. Where pertinent, other routes of transmission are indicated. It should be remembered that direct contact with infected persons, their feces, saliva, blood or clothing is also potentially infectious.

TABLE 11

Water-Borne Pathogens: Health Effects, Geographic Distribution and Sensitivity to Chlorination

Organism	Effects	Distribution	Water Treatment/Prevention
Bacteria			
Salmonella	Typhoid fever is incapacitating, requiring 1 to several weeks for recovery.	Worldwide	Chlorination effective/ Identify Typhoid carriers, Immunization[12]
Shigella	Bacillary dysentery can be moderately severe or asymptomatic. *Shigella dysenteriae* is the most virulent and can cause debility for weeks.	Worldwide	Chlorination effective.
Vibrio cholerae	Cholera is a very severe intestinal disease causing severe fluid and electrolyte losses, which, if not replaced, causes death in 50% of cases. Treated cases are physically weak for several weeks.	Worldwide - most prevalent in Asia preceding rainy seasons.	Chlorination effective/ Immunization[12]
Escherichia coli (enteropathogenic types)	Gastroenteritis of variable intensity, but often debilitating for 1 or more days.	Worldwide	Chlorination effective
Clostridium botulinum	Botulism: nausea, vomiting, pain, nervous system effects, weakness, unsteadiness, blurring of vision, dysphagia, dysparthria. Death results from respiratory paralysis and occurs in 50-60% of cases. Extremely potent; <<1 mg of a pure toxin may be lethal.	Worldwide, but almost always as contaminant in canned foods. The toxins are potential CBR agents.	FAC > 2 mg/l inactivates the most resistant toxins in less than 30 minutes[16]./ Apart from use as a possible CBR agent, toxins are rarely found in water supplies in sufficient quantities to be a health problem.
Bacillus anthracis	Anthrax: the infection is spread by direct contact, inhalation or ingestion of spores. Severe inflammation and ulcers at point of entry. Death results in 20% of cases from a toxin produced by the bacteria.	Where infected animals, especially sheep, are or have been raised. Also from infected animal hide and fur products. A potential CBR agent.	Spores are very resistant to chlorination: ~ 5 mg/liter, FAC in 1 hour, at 4°C, and pH 6.2 are required for 99.99% kill; ~ 10 mg/liter FAC in 1 hr. at 22°C and pH 8.6 are required for 99.99% kill[7].
Enteric Viruses			
Hepatitis A	Infectious hepatitis is variable in symptoms, ranging from none and mild cases resembling flu with gastroenteritis to extremely debilitating liver disease accompanied by fevers and chills, anorexia, headache, vertigo, weakness. Symptoms can persist for many weeks.	Worldwide	Chlorination: FAC > 2 ppm after 30 minutes/ Proper human sanitation and hygiene can prevent large outbreaks
Enteroviruses (6 types)	Sporadic outbreaks: - Bornholm's disease (Devil's Grip, epidemic myalgia) - aseptic meningitis with rash - acute undifferentiated respiratory and non-respiratory illnesses (common cold syndrome) - polio myelitis - meningitis and encephalitis Rare: - vesicular lesions of the hand, foot and mouth - myocarditis and pericarditis	Worldwide	Variable susceptibility to chlorination (see TABLE I C-2.2) [Importance of water-borne route is unclear; person to person contact is the presumed major route of transmission] / Immunization for polio.[12]

TABLE 11

Water-Borne Pathogens: Health Effects, Geographic Distribution and Sensitivity to Chlorination

Organism	Effects	Distribution	Water Treatment/Prevention
Protozoan and Metazoan Parasites			
Schistosoma haematobium, schistosomes or bilharzia worms, blood flukes; vesicular blood fluke *S. japonicum*, Japanese blood fluke *S. mansoni*, Manson's blood fluke	Schistosomiasis is a serious disease marked by a variable, usually self-limiting fever several weeks following infection. Years later, complications due to liver involvement as well as lungs, urinary tract and central nervous system, appear.	Worldwide with higher prevalence in Africa, Madagascar, Middle East	Less resistant than cysts of ameba, but more resistant than bacteria. Direct penetration of skin from contact with infested waters is the more common means of infection. Decontaminate water used. Can be transmitted by air to unprotected water supplies. Filtration is an effective treatment.
Ascaris lumbricoides, common roundworm	Ascariasis affects lungs and causes fever, cough, occasional hemoptysis. The intestines, when heavily infected, may become obstructed with intussusception, volvulus, appendicitis and hernial strangulation.	Worldwide, very common in tropics	Sensitivity to chlorination is uncertain/ Food is a major source of infestation.
Taenia solium	Cysticercosis may go unnoticed for years after infection until brain involvement occurs, causing epilepsy, personality changes, etc. Other organs affected: subcutaneous tissues, eye, meninges, muscles, heart, liver, kidney.	Worldwide	Sensitivity to chlorination is uncertain/ Man can ingest the embryophore from food or water contaminated with canine feces. Ingestion of improperly treated pork has been the more usual route of transmission.
Dracunculus medinensis (guinea worm)	Dracontiasis usually presents as a skin ulceration at site of emergence of female worm.	Africa, Arabia to Pakistan; locally elsewhere in Asia	Water treatment usually removes the infected water fleas which harbor the organism. Chlorination kills water fleas.
Echinococcus granulosus, E. multilocularis (hydatis worm)	Hydatid cysts usually cause liver symptoms 20-30 yrs. after infection, although other organs are affected.	Worldwide: especially where triad of 1) canines (dog, fox, wolf), 2) sheep and 3) man occurs	Effectiveness of chlorination is uncertain. Man is infected by the dog; eggs are present in mouth, feces and coat./ Personal hygiene is especially important where canines may harbor disease.
Enterobius vermicularis (pinworm)	Enterobiasis is usually not serious, but can be aggravating.	Worldwide	Waterborne route uncommon./ Egg-contaminated bed clothes, underwear and bed linens and infection usually results from poor personal hygiene.
Ancylostoma duodenale, Necator americanus (hookworms)	Hookworms cause blood loss and possible consequent anemia and may cause transient pruritis when they enter the body through the skin.	Worldwide, tropics and North America	Effectiveness of chlorination is uncertain./ Skin penetration in common. Prevention based on proper sanitation of human waste.

TABLE 11

Water-Borne Pathogens: Health Effects, Geographic Distribution and Sensitivity to Chlorination

Organism	Effects	Distribution	Water Treatment/Prevention
Protozoan and Metazoan Parasites			
Isospora belli and *I. hominis*	Coccidiosis is quite often subclinical, but can cause mild diarrhea, fever, malais and lassitude.	Tropics and subtropics Rumania, Holland, Chile	Resistance to chlorination?
Balantidium coli	Balantidiasis causes symptoms in 1/5 of infected patients: chronic mild diarrhea sometimes alternating with periods of constipation.	Worldwide but is only common where pigs and man are in close contact	Resistance to chlorination?
Giardia lamblia	Giardiasis is usually asymptomatic, although mild diarrhea, often alternating with constipation, steatorrhea, malabsorption of fats, anorexia may occur.	Worldwide	Resistance to chlorination similar to *E. histolytica*./ Filtration can significantly reduce number of cysts in water
Trichuris trichiura	Infectious, usually asymptomatic. Heavy load of worms may cause cholic and bloody diarrhea. Difficult to treat.	Worldwide, but usually in tropics	Resistance to chlorination?
Entamoeba histolytica	Ambiasis causes a variable diarrhea from none to severe with ulcerative colitis and occasional life-threatening peritonitis.	Worldwide, prevalent in tropical climates	Relatively resistant to chlorination, requiring minimum of 2 to 10 ppm (FAC), depending on pH and temperature/ Contaminated uncooked food is a more important route of infection than via water supply.
Toxoplasma gondii	Toxoplasmosis: onset of disease is slow while organisms establish themselves in tissues throught the body. Generalized lymph node enlargement, fever and malaise develop about 2 weeks after ingestion. Tissue destruction leads to problems of the nervous system, eyes, lungs, liver and skin.	World-wide but prevalent in warm, moist climates and where man is in close association with cats.	Resistance to chlorination? /Direct contact with infected cats or contaminated soil and unwashed vegetables; contaminated meats.

Sources: Brazis et al.[7], Block[13], Jawetz et al.[14], Berg et al.[15], Brazis et al.[16], Beeson and McDermott[17]

DOCUMENTATION*

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2. TM 5-700. "Field Water Supply," July 1967.[b]

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10. Craun, G.F., L.J. McCabe and J.M. Hughes. "Water-borne Disease Outbreaks in the U.S. - 1971-1974." J. Am. Water-Works Assoc. 68: 420-424, 1976.

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12. TB MED 114 "Immunization". May 1970.[b]

13. Block, S.S., ed., Disinfection, Sterilization and Preservation. 2nd ed. Lea and Febiger, Philadelphia, 1977. pp. 167-219, 705-722.

14. Jawetz, E., J.L. Melnick and E.A. Adelberg, eds., Review of Medical Microbiology. 12th ed. Lange Medical Publications, Los Altos, California, 1976, pp. 492-524.

15. Berg, G., H.L. Bodily, E.H. Lennette, et al., eds. Viruses in Water. American Public Health Associates, Inc., Washington, D.C., 1976.

*For explanatory notes a-g, see page 186.

16. Brazis, A.R., A.R. Bryant, J.E. Leslie, R.L. Woodward, and P.W. Kabler, "Effectiveness of Halogens or Halogen Compounds in Detoxifying Clostridium Botutinum Toxins," Am. Water-Works Assoc. J. 51:902-912, 1959.

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19. Johnson, "Disinfection: Water and Wastewater", Ann Arbor Science, 1977.

20. Waterborne Transmission of Giardiasis, Proc. of Symposium in Cincinnati, Ohio, Sept. 1978. EPA publication (EPA-600/9-79-001), June 1979.

21. Hoye, R.L., Logsdon, G.S. and Symons, J.M., Alternative Filtration Methods for Removal of Giardia Cysts and Cyst Models. J. Amer. Water Works Association, 73, No. 2, p. 111-118, Febrary 1981.

DATA GAPS AND RESEARCH NEEDS

1) The potential for destruction of water-borne parasites at the free available chlorine residuals specified in TB MED 229 should be more carefully evaluated and documented for specific species.

2) Methods should be developed for testing the presence of parasitic organisms in unfiltered water.

3) A more exhaustive literature search should be undertaken to determine if additional data on the effectiveness and limitations of disinfection by iodine and chlorine is available.

4) Training of soldiers should be improved so that they fully appreciate the necessity of drinking only treated water, and the correct use of iodine tablets in the field should be emphasized in training.

5) While passive immunization has usually occurred during childhood to many local enteric viruses, geographical differences in species and strains exist and some species are relatively resistant to chlorination, therefore, the potential risks to soldiers when they are transferred abroad need further investigation.

6) Specific epidemiological data which show the actual etiological cause of diseases in military situations should be obtained because these diseases have a variety of modes of transmission, including the water-borne route.

7) There is a potential conflict between increasing safety and decreasing palatability by adding more chlorine. A better defined relationship should be established and procedures for obtaining both palatable and potable water for field documented use.

8) The Surgeon General's Office favors a single source (all potable) water distribution system, which avoids accidental use of a non-potable source for drinking. However, the risk and benefits associated with multiple source versus single source distribution should be further investigated in the context of various military situations.

TOPIC 2: Environmental Contamination/Opportunity Poisons

Situation: *Operational Environment - All Environments*
Operational Characteristics - All units

REQUIREMENTS

General:

Potable water must not contain any substance that would cause adverse physiological effects...[1]

Criteria:

TB MED 229[1] specifies in Appendix G water quality standards for field water supplies as follows:

Chemicals:	Short Term 7 Days	Long Term 7 Days
Arsenic	2 mg/l	0.2 mg/l
Chloride	600	250
Cyanide	20	2
Magnesium	----	150
Sulfate	----	400
Total dissolved solids	----	1500
Pesticides:	No specific criteria	
Organic chemicals:	No specific criteria	

These standards are the same as specified in TM 5-700[2], QSTAG-245[3], and STANAG-2136.

Surveillance:

See Section III D, Detection & Analysis of Water Contamination.

Effectiveness:

Current water quality criteria for protecting the health and performance capabilities of soldiers in the field are generally regarded as inadequate[4,5,6,7,8,9]. The principal concern in the referred documentation is protection from chemical warfare agents, not environmental contaminants.

It is observed that two chemicals which have severe acute toxicity potential via the water supply (arsenic and cyanide) have specified limits, while other chemicals likely to be encountered in the water supply (e.g., barium) do not have specified limits. However, a large number of very toxic, sufficiently soluble, industrial and agricultural chemicals are not listed. Conspicuously missing, for example, are all of the organo-phosphorous pesticides, some of which are moderately persistent in the environment and may resist typical treatment, such as chlorination.

Furthermore, there is a need for a way to assess risks associated with variations from the prescribed water quality criteria. It has been stressed that the Field Surgeon cannot readily help the Field Commander make overall risk assessments (e.g., heat casualties vs. "poison" casualties vs. battle casualties) without the aid of a toxicological data base and hazard assessment methodology[6,7].

POTENTIAL HEALTH EFFECTS

The National Research Council, (NRC), in Drinking Water and Health[10], discussed many of the environmental pollutants. It lists organic pesticides and other organic contaminants and estimates an acceptable daily intake (ADI), based on a no-effect daily dose. [Note that the ADI includes a variable uncertainty factor.]

Thus, the ADI is a conservative estimate, especially in the absence of adequate experimental data. Furthermore, the suggested no adverse effect level from water is based on the assumption that the major exposure to these chemicals is from sources other than water. This latter assumption may not be appropriate to the military situation.

It is not possible in this study to discuss all the potential environmental contaminants or to provide detailed documentation of their health effects even where the data are available. Four examples are briefly reviewed below which illustrate the need for extensive revision of the current field water quality criteria.

Arsenic

Arsenic is an acute and a chronic poison which has been found in Middle East groundwaters at concentrations exceeding World Health Organization (WHO) standards. The oral lethal dose is highly dependent on the form of arsenic occurring. Minimum lethal doses as low as 1-2 mg/kg have been reported. The symptoms of acute poisoning are severe gastrointestinal upset with nausea, vomiting, diarrhea and severe abdominal pain.

The general order of toxicity is $AsH_3 > As^{+3} > As^{+5} >$ R-As-X. Few data exist upon which to estimate the dose-response relationship. NRC (1977)[10] cited several studies which permit a rough approximation. Mitzuta et al.[11] reported on 220 patients of all ages who had been poisoned by contaminated soy sauce, with an average estimated ingestion of 3 mg arsenic (probably as calcium arsenate) daily for 2-3 weeks. In this group, 85% had facial edema and anorexia; fewer than 10% had exanthemata, desquamation and hyperpigmentation, and about 20% had peripheral neuropathy. Electrocardiograms were abnormal in 16 of 20 patients. Neurological symptoms became prominant as much as 2 weeks after arsenic ingestion was discontinued.

Another incident was recounted in which dermatological manifestations and some deaths, particularly among children, occurred that were traced to a water supply containing arsenic at 0.8 mg/liter.

A case report of a patient who ingested approximately 8.8 mg of arsenic trioxide daily for a total of 28 months revealed signs of arsenic poisoning (hyperpigmentation, gastrointestinal upset) after 13 months, and paresthesias and weakness after 2 years.

These studies suggest that the field water quality criteria for arsenic may be too high (under conditions of increased consumption of water) to meet the no-effect level. A water intake of 13 liters/day would give a does of 26 mg/day, which may result in severe toxicity, and affect performance of soldiers in the field.[12]

Cyanide

Cyanide is an unusual pollutant in most U.S. water supplies; documented cases of levels in water exceeding 0.2 mg/l are extremely rare. Absorption from the gut is rapid and complete and the mean acute lethal dose in a man is between 50 and 200 mg. However, sublethal doses of cyanides are rapidly metabolized, so that subacute exposures - even those that may produce transient responses, i.e, augmentation of respiration, hypertension - appear to be tolerated on a daily basis without persistent ill-effects. Thus, cyanides have a low cumulative toxicity hazard. A detoxification rate of 1.2 mg/min/ poison was cited[13] which suggests that a relatively continuous exposure (as through drinking water) at this rate can be tolerated.

Parathion (A hypothetical opportunity poison)

Parathion has been used extensively throughout the world as an agricultural insecticide. Pharmacologically, it is a cholinisterase inhibitor like the nerve agents but much less potent and less hazardous due to much lower volatility. It has a number of attributes as an opportunity poison.

- Solubility: 20 mg/liter
- Potency: LD_{50} = 3-5 mg/kg = 210-350 mg/70 kg person
- Nature of toxicity: irreversible cholinesterase inhibitor, cumulative toxicity potential
- Stability and resistance to chlorination: see below
- Availability: readily available

The stability of pesticides undergoing water treatment has been researched for obvious reasons. In a recent monograph, Gomaa and Faust[14] reported that parathion was oxidized to the more toxic pesticide paraoxon by $KMnO_4$, Cl_2, or ClO_2. Approximately 22 mg/liter Cl_2 was required to completely oxidize parathion in 1 hour at pH 7.4. Twenty-five percent was converted to paraoxon and 75% to much less toxic products. About twice as much Cl_2 was required to completely hydrolyze 1 mg/liter paraoxon. Paraoxon is the active metabolyte formed after parathion is ingested, causing a delay of several hours before toxicity appears. It is an irreversible inhibitor of cholinasterase and therefore has a cumulative toxicity.

Magnesium and Sulfates

The criteria level in TB MED 229 appear to be based on the laxative effects of magnesium and sulfates, especially in combination, and their adverse effect on palatability. A laxative effect is apparent in some people unaccustomed to magnesium sulfate at about the levels (combined) specified in the criteria. Sulfate alone appears to have no laxative effect until levels of 1000 mg/liter are reached. This effect, if severe, will indirectly affect fluid balance due to diarrhea, there are no other significant health effects[10].

Maximum levels specified in the criteria, if present in treated water, could inhibit water consumption under conditions where increased water consumption is required. Magnesium imparts an astringent taste to water which is detectable at about 100 mg/l. Sulfates also impart taste to water which is reported to be detectable at 300-400 mg/liter[10]. No data has been found describing the interaction of heat/climatic water demand and high magnesium sulfate levels.

DOCUMENTATION*

1. TB MED 229. "Sanitation Control and Surveillance of Water Supplies at Fixed and Field Installations." August 1975.[f]

2. TM 5-700. "Field Water Supply" July 1967.[f]

3. QSTAG 245, American-British-Canadian-Australian Armies Standardization Program, 19 May 1972, Subject: Minimum Requirements for Water Potability (Short and Long Term Use).[e]

4. Letter. SGRD-UBG, USAMBRDL, 4 December 1980, Subject: Special Working Party on the Minimum Requirements for Water Potability in the Field (SWP/MRWP).[e]

5. Interview with personnel at MERADCOM, Fort Belvoir, VA. (Appendix A, 1.5).[b]

6. Interview with personnel at Department of Preventive Medicine, Academy of Health Sciences, Ft. Sam Houston, TX (Appendix A, 2.1).[b]

*For explanatory notes a-g, see page 186.

7. Interview with personnel at Uniformed Services, University of Health Services Bethesda, MD (Appendix A, 2.6).[b]

8. Interviews with personnel at FORSCOM Surgeon's Office, Fort McPherson, GA (Appendix A, 3.3).[b]

9. Interview with personnel at Surgeon's Office, H.Q., XVIII Airborne Corps, Fort Bragg, N.C. (Appendix A, 3.4).[b]

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12. Letter. DRDAR-CL, USAARDCOM, CSL, 28 Nov. 1980, Subject: Field Drinking Water Standards for CW Agents.[e]

13. U.S. Environmental Protection Agency. Ambient Water Quality Criteria for Cyanides. Office of Water Regulation and Standards, Criteria and Standards Division. Washington, D.C. 1980. pp. C-14 - C-23.

14. Gomaa, H.M. and S.D. Faust. "Removal of Organic Pesticides from Water to Improve Quality." In: Pesticides in Water and Soil, Guenzi, W.D., ed. Soil Science Society of America, Inc., Madison, Wisconsin, 1974. pp. 420-429.

DATA GAPS AND RESEARCH NEEDS

1. The doctrine available in TB MED 229 is clearly inadequate in terms of the chemicals covered and the quantitative values of water quality criteria, which are published. The number of chemicals specified should be greatly expanded and the numerical criteria revised as necessary.

2. Available toxicity data on environmental contaminants published by EPA as part of its promulgation of water quality criteria, should be reviewed and adapted to military use as a set of "interim" water quality criteria for military situations.

3. A methodology should be developed to select a practical sub-set of available industrial and agricultural chemicals based on their risk potential and appropriate water quality criteria should then be developed.

4. The potential for specific contaminants to be introduced into the water supply should be investigated for different military situations[4]. Concentration levels necessary to pose a health hazard or to make the water unpalatable should be investigated.

5. There is a need to develop a comprehensive risk-analysis methodology to be used by the field surgeon and staff, so that the relative risks from all sources can be compared, depending on the combat situation and supplies available.

6. Detection/analysis and treatment capabilities and alternative sources of water supply must be considered in conjunction with re-evaluation of water quality criteria. For example, Go/No-go test kits do not permit consideration of total dosage, given a particular water consumption rate, and thus would limit the field commander's staff when making necessary trade-off decisions.

TOPIC 3: NBC Contamination of Water

Situation: *Operational Environment - All Environments*
Operational Characteristics - All Units

REQUIREMENTS

General:

Potable water must not contain any substance that would cause adverse physiological effects ...[1]

Criteria:

Chemical, biological and nuclear criteria for field water supplies are set forth in TB MED 229, Appendix G[1], TM 5-700[2], and QSTAG-245[3] as shown in Table 12 and are based on consumption of 5 liters/day of water. QSTAG-245 (but not TB MED 229) provides for proportional reduction of the standards for increased water consumption (20 liters/day)

Surveillance:

See Section III D, Detection and Analysis, Topic 4.

Effectiveness:

The chemical agent criteria were developed in the 1960's from a limited health effects data base obtained using volunteers in a non-stressful environment. Exposures were short term, i.e., less than 7 days.

A meeting of the Research Laboratories Human Estimates Committee, 1969[4], concluded, based on limited human toxicity data, that the standard for mustards should be reduced from 2 mg/l to 0.2 mg/l. Apparently this suggestion was never adopted[5]. The committee also concluded that the degredation of products in water may be more toxic than the original nitrogen mustard or sulfur mustard.

A recent review[8] of the current criteria level for nerve agents GA, GB, GD and VX concluded that 0.02 mg/liter is an adequate criteria level at a water consumption rate of 5 liters/day, but not at a consumption rate of 20 liters/day. (The data base reflects subjects who were healthy men, not under stress, and co-exposure to other toxic chemicals was absent).

The adequacy of the Field Water Quality Criteria has been questioned frequently, as indicated by the documentation reviewed[5,6,7,8]. (Also, see references 4, 5, 6, 7, 8, 9 from previous topic). Most interest in re-evaluation and revision of the criteria appears to be centered on chemical agents.

Field Experience:

None documented.

TABLE 12

WATER QUALITY CRITERIA FOR NBC AGENTS
(Based on consumption of 5 liters/day)

Agent	Short term consumption	Long term consumption
Chemical:	<7 days	>7 days
Hydrogen Cyanide	20.0 mg/l	2.0 mg/l
Lewisite	2.0	0.2
Mustard	2.0	2.0
Nerve agents	0.02	—
Radiological:	(see note)	
Gross beta activity	—	1000 pc/l
Strontium 90	—	10
Radium 226	—	3
Biological:	No specific standards for biological warfare agents.	

Note: For short term consumption, a numerical standard is considered unnecessary. This is based on the assumption that if the external radiation hazard is sufficiently low to permit occupation of the water point, the water is suitable for consumption over a seven day period[1,4].

POTENTIAL HEALTH EFFECTS

1) Chemical Agents

Brief summaries of the toxic effects of nerve agents, blister agents and incapacitating agents are given in FM 3-10[9]. Further details are apparently discussed in FM 3-10B (classified material). TB MED 282[10] discusses symptoms, and management of anticholinesterase intoxication (i.e., nerve agents and organo-phosphorus pesticides). These agents are designed to cause casualty or to incapacitate. However, the toxicological data base generally describes exposure routes other than water consumption (see for example reference 9).

2) Radiological

Health effects of radiation are described in Reference 12.

3) Biological Agents

For information on potential health effects see Section III C, Topic 1.

DOCUMENTATION*

1) TB MED 229. "Sanitation Control and Surveillance of Water Supplies at Fixed and Field Installations." August 1975.[f]

2) TM 5-700. "Field Water Supply" July 1967.[f]

3) QSTAG 245. American-British-Canadian-Australian Armies Standardization Program, 19 May 72, Subject: Minimum Requirements for Water Potability (Short and Long Term Use).[e]

4) Robeck, G.G., et al. Water Contamination in Fallout Areas, PB-260328, May 1958.[g]

5) Albertson, J.N., Jr. Field Drinking Water Policy and Operational Capability Oversights, SGRD-UBG (undated).[e]

6) SMUEA-RILD-TIC, HQ, Human Estimates for Allowable Concentrations of Agents in Drinking Water, September 19, 1969.[e]

7) DRDAR-CL, USAARDCOM CSL, Field Drinking Water Standards for CW Agents, November 28, 1980.[e]

8) SGRD-UBG-O, USAMBRDL, Assessment of the Data Base Available on Biologic Effects of CW Agents. November 3, 1980.[e]

*For explanatory notes a-g, see page 186.

9) FM 3-10. Employment of Chemical and Biological Agents, Chapter 2, March 1966.[f]

10. TB MED 282 "Anti-cholinesterase Intoxication Pathophysiology, Signs and Symptoms and Management," January 1970.[f]

11. McNamara, B.P. and F. Leitnaker. Toxicological Basis for Controlling Emission of BG into the Environment. Edgewood Arsenal Special Publication EASP-100-98, Department of the Army, 1971.

12. FM 3-12. Operational Aspects of Radiological Defense, August 1968.[f]

DATA GAPS AND RESEARCH NEEDS

The current water quality criteria for agents in field water supplies should be reevaluated. Five major issues have been raised; some important aspects of each issue which should be investigated are listed below:

a) Adequacy of the toxicological data base:

- a complete assessment of the range of effects and the dose/ response relationships for toxicants should be considered.
- include, as appropriate, experimental animal data.
- evaluate new NBC agents (e.g., special biological agents, substances which cause water to be unpalatable and opportunity poisons).

b) Adequacy of criteria under conditions of increased consumption:

- effects of agents on voluntary consumption.
- a recasting of criteria in terms of acceptable daily dosage, instead of concentration, creating a need for quantative vs. qualitative analysis sets.

c) Tolerable effects:

- policy concerning the potential risk of cancer to certain agents should be formulated, given the Vietnam experience with agent orange and nuclear weapons testing during and following World War II.
- risk analysis methodologies need to be developed to permit a more rational choice among hazards.

d) Toxicity interactions:

- more than one toxicant and toxicity of hydrolysis products.

- relative importance of the ingestion route vs. inhalation and skin contact, total body burden from all routes.

- co-exposure to physiological stress such as heat, increased physical activity, and various disease states.

e) Capabilities of water analysis sets and water treatment methodologies:

- the criteria levels become the principal focus in the development of detection methodology, widely different criteria levels for a particular compound can dictate widely different approaches to development of water analysis test sets.

- what agents are likely to be introduced into the water in NBC warfare; consider stability, solubility and potency,

- what is the impact on surface water of airborne releases of NBC agents.

- evaluate the advantages and disadvantages of go/no-go water quality tests in comparison to quantitative tests.

TOPIC 4: Palatability of Drinking Water

Situation: *Operational Environment - All Climates*
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

Potable water must not contain any substances that would ... cause water to be unpalatable to the extent that a non-potable source might be substituted by the user[1].

a. For short-term consumption, water should be reasonably clear, reasonably free from taste or odor due to hydrogen sulfide, phenols or other substances.

b. For long-term consumption, water should not have a turbidity exceeding 5 units, should be free from taste or odor and should not have color exceeding 20 units.[2]

Palatability of water is a term which describes the characteristic of being pleasing to the sense of taste. To be palatable, water should be significantly free from color, turbidity, taste and odor, and should be cool and aerated.[3]

(TB MED 507, "The Etiology, Prevention, Diagnosis, and Treatment of Adverse Effects of Heat,"[4] does not discuss palatability).

Effectiveness:

These criteria are clearly not very specific and for the most part, allow considerable latitude for subjective judgment. Considerations of potability may tend to overshadow those of palatability even though the two considerations are not necessarily incompatible. Improvement in both potability and palatability may more frequently be limited by a lack of planning and an unawareness of the value of doing so than by actual limitations of the water treatment procedures.

The necessity of maximizing palatability, to enhance voluntary drinking, to help prevent heat casualties and to maintain optimum physical and mental capabilities of soldiers is recognized by some segments of the armed services, but is not reflected in current doctrine.

Field Experience:

Adolf, et al.,[5] conducted several experiments to determine the effect of certain aspects of palatability on voluntary re hydration of men working or marching in the desert. In one series of studies, they found voluntary rehydration was significantly improved by cooling water (55°F water was better than 82°F, 9°F was better than 109°F). Plain water at 55°F was found to be markedly better (twice as much as voluntarily consumed) than salted water (0.1% NaCl) at 55°F. (0.1% is the recommended level of addition in TB MED 507 to replenish salt lost in sweat.) Plain cool water was, overall, the most acceptable for drinking and resulted in the highest voluntary rehydration when compared to a variety of fruit-flavored waters.

Sohar, et al.[6] found that voluntary dehydration was largely prevented when fluids were available every hour of the day during a 15-20 minute rest stop.

Men walking in the desert preferred cold water at 10-15°C over water at 20-30°C. In direct comparisons of different beverages, citrus juice or citrus flavored water were preferred over unflavored water. Soda water and several carbonated beverages were not preferred, because they gave a feeling of fullness, and tended to discourage drinking. Beer and milk were found to be poor beverages, due to after-effects (intoxication and diarrhea, respectively). Voluntary dehydration even during physical effort was reduced if cool water or cool citrus beverage was available and sufficient time was made available to "quench thirst". (15-20 minutes of rest). The Israeli Defense Force doctrine for preventing heat casualties has incorporated these and other findings[7]: (see page 39).

Rodgers, et al.[9] reported that soldiers in Vietnam added soft drink mix (Kool Aid) to their drinking water to improve taste. Ascorbic acid is present as a preservative in these mixes. It reacts with iodine, reducing the disinfecting capability of the iodine tablet.

POTENTIAL HEALTH EFFECTS

The potential health effects are indirect: 1) Unpalatable water will not be consumed as readily as palatable water. Since voluntary dehydration is already a serious threat in hot climates, even when water is moderately acceptable and available, the effect of unpalatable water on consumption would exacerbate heat problems (see water consumption section, individual consumption in a hot climate); 2) Non-potable sources may be substituted for an unpalatable but potable source. The possible consequences of consuming non-potable water are discussed elsewhere in this section.

DOCUMENTATION*

1) TB MED 229. "Sanitation Control and Surveillance of Water Supplies at Fixed and Field Installations." August 1975.[f]

2) AR 40-5. Health and Environment, September 1974.[f]

3) TM 5-700. "Field Water Supply," July 1967.[f]

4) TB MED 507 "The Etiology, Prevention, Diagnosis and Treatment of Adverse Effects of Heat." July 1980 (Supercedes TB MED 175)[f]

5) Adolf, E.F., et al. The Physiology of Man in the Desert. Interscience Publishers, Inc., New York, 1947.

*For explanatory notes a-g, see page 186.

6) Sohar, E., J. Kaly, and R. Adar. The Prevention of Voluntary Dehydration," Environmental Physiology and Psychology in Arid Conditions.[e]

7) Hubbard, R.W. "An Analysis of Current Doctrine in Use (USA vs. IDF) for the Prevention and Treatment of Heat Casualties Resulting from Operations in the Heat." Prepared for Commanding Officers' Conference, 4th MAW/MARTC, New Orleans, 2-4 October, 1978.[e]

8) Field interview with personnel at BSD/SATL, ARIEM, March 10, 1981.(Appendix A, 1.7)[b]

9) Rodgers, M.R., A.M. Kaplan, J.J. Vitaliano, E. Pillion. Military Individual and Small Group Water Disinfecting Systems: An Assessment. Military Medicine 14(4):268-277, 1977.

DATA GAPS AND RESEARCH NEEDS

1) A variety of flavoring agents should be tested to answer the following questions.

   - Can flavoring agents enhance voluntary consumption of good quality water or poor quality water (e.g., highly chlorinated)?
   - Do the flavoring agents interfere with disinfection?
   - Are certain flavoring agents better than others under conditions of physical exertion in a hot climate?
   - Does the palatability of flavored water vary with quality, type of disinfection (e.g., chlorine vs. iodine) and/or duration of consumption?

2) The alternative means of cooling water should be clearly documented in Army manuals. Avoidance of contamination should be stressed.

3) Equipment suitable for cooling water should be developed.

4) The benefits of using flavoring agents voluntarily, or by administration at the water point (e.g., Lyster bag), should be compared.

TOPIC 5: Criteria for Wastewater Recycle/Reuse

Situation: *Operational Environment - All Climates*
Operational Characteristics - Company and Larger Size Units

REQUIREMENTS

There is at present no approved doctrine and no established water quality criteria for wastewater intended for recycle or reuse. Suggested requirements are:

1) Wastewaters recovered and treated for nonpotable reuse purposes shall cause no deleterious effects on the health of the command.

2) Wastewater treatment processing shall be simple, reliable, adaptable, to the field environments and readily transportable on available field military vehicles.

Interim reuse water quality criteria were proposed by the Office of the Surgeon General[1,2] as part of the "MUST" concept (Medical Unit, Self-Contained, Transportable). These criteria are incomplete in that they do not provide toxic organic or microbiological criteria.

A methodology for evaluating recycle/reuse criteria has been proposed[3] which considers the variation in exposure from different applications and takes into account the cumulative dose from ingestion, inhalation and absorption through the skin.

Equipment:

1) Equipment consisting primarily of existing standard military components has been assembled, tested and is available in military supply depots for the collection and treatment of laundry and shower wastewater to permit discharge to the environment.[4]

2) Research indicates that pollution abatement, shower and laundry wastewater systems can be modified, with additional standard military components, to make the treated wastewaters acceptable for shower and laundry reuse purposes.

3) Proposed equipment can be manually loaded or off-loaded from military field vehicles, but assembled units are difficult to operate and maintain in adverse weather conditions.

4) Equipment processes require one additional MOS trained operator per shift for O & M duties.

5) The U.S. Navy is developing a shower and laundry field unit housed in a shelter with the capability to treat and recover wastewater for recycling purposes[7].

Effectiveness:

1) Carbon sludges generated in wastewater treatment processes are difficult to remove and their disposal in the field is accomplished by burial.

2) Optimum activated powder carbon polymer dosages have not been developed for the wide variations of surfactants, soaps and raw water qualities which are anticipated.

3) Existing wastewater treatment processes may not be effective against NBC contaminants.

4) Full scale experimental systems using ultrafiltration, reverse osmosis, and UV-ozone have been extensively evaluated for treatment of hospital wastewaters, but have not been adopted for field use.

Field Experience:

1) Water resource planning for arid and regions where fresh water supplies are scarce, require that reuse of wastewater be considered for augmentation of non-potable requirements. However, field experience to define non-potable water criteria, and design, collection and treatment systems is not available.

2) Treated wastewater from full-size field laundry and bath units was suitable for discharge to the environment.[6]

3) Field performance data is not available for non-potable recycled/reuse of wastewaters in specific applications.

4) Field methods for handling of activated carbon and disposal of carbon sludges is cumbersome and inefficient.[6]

POTENTIAL HEALTH EFFECTS

1) Toxic effects from inadequate treatment of wastewater.

2) Toxic effects from reuse of treated wastewater for a purpose other than its designated application.

3) Toxic effects from improper disposal of concentrated waste products from treatment processes.

DOCUMENTATION*

1) Dep. Army Med. Res. Develop. Command. (USAMRDC). "Request for Proposal (RFP) DAMD17-74-R-4751. MUST Water Treatment and Water Purification Elements," Washington,D.C., (15 October 1973). [Quoted in Reference 2]

2) Lambert, W.P., and L.H. Reuter, "Water Reuse within an Army Field Hospital," Proc. 3rd Nat. Conf. on Water Reuse, p. 447 Cincinnati, OH, 1976

3) Shooter, D. and Anderson, R.C. Development of Data Base Requirements for Human Health Based Water Quality Criteria for Military Recycle/Reuse Applications. U.S. Army Medical Research and Development Command, Report Contract No. DAMD17-79-C-9139. June 1980.[e]

4) Laundry Wastewater Treatment Kit, Technical Manual, Operator and Organizational Maintenance Manual, FSCM 97403-188. MERADCOM, Fort Belvoir, VA, March 1978.

5) "Interim Water Quality Criteria for Shower and Laundry Reuse/Recycle" ltr. to HQDA (DASG-PSP-E) from USAMBRDL, Fort Detrick, MD, 22 October 1980.[e]

6) "Treatment of Wastewaters from Military Field Laundry, Shower and Kitchen Units," report 2061, MERADCOM, Ft. Belvoir, VA., May 1973.

7) Field Interview with U.S. Navy Civil Engineering Laboratory, Port Huenene, (Appendix A.5.1).[b]

8) Cogley, D.R., W. Foy, W.G. Light, M. Mason and J.C. Eaton, "Evaluation of Health Effects Data on the Reuse of Shower and Laundry Waters by Field Army Units," Final Report, Walden Div. of Abcor, Inc., April 1979, AD AO76302.[a]

9) Schmidt, C.J., E.V. Clements, III, and S.P. Shelton, "Cascade Water Reuse," SCS Engineers, Long Beach, CA. July, 1977, for Civil and Environmental Engineering Development Office, Air Force Systems Command, Tyndall Air Force Base, Florida.

10) Botros, M., "Laboratory Results of Laundry Wastewater Treatment," Final Report to U.S. Army, Facilities Engineering Support Agency, Fort Belvoir, VA. No. FESA-RT-2017, April 1976.

11) Ford, S.W., "Feasibility of Recycling Laundry Wastewaters at Military Quartermaster Laundries," Final Report to U.S. Army Facilities Engineering Support Agency, Fort Belvoir, VA, No. FESA-RT-2016, March 1977.

*For explanatory notes a-g, see page 186.

12) Kleper, M.H., R.L. Goldsmith and A.Z. Golan, "Demonstration of Ultrafiltration and Carbon Adsorption for Treatment of Industrial Laundering Wastewater," Final Report to EPA, Industrial Pollution Control Div., PB-287-830, August, 1978.g

13) Aulenback, D.B., P.C. Town and M. Chilson, "Treatment of Laundromat Wastes," Final Report to EPA, Office of Research and Monitoring, PB227-369, September 1971.g

14) See, G.G., K.K. Kacholia and R.A. Wynveen, "Control and Monitor Instrumentation for MUST Water Processing Element," Final Report Contract No. DADA 17-73-C-3163, Life Systems, Inc., Cleveland, OH, June 1975.

15) Bhattacharyya, D., Journal of Water Pollution Control Federation, p. 845, May 1978.

16) Witherop, S.O., and Emmett, E.A., "The Toxicity and Irritancy of Ultrafiltrates of Non-Sanitary Military Wastes," Final Report to U.S. Army Medical Research and Development Command, Contract DAMD 17-76-C-6006.

DATA GAPS AND RESEARCH NEEDS

1) Acceptable, health based water quality criteria must be defined as a first step in promoting wastewater recycle reuse.

2) Better identification of toxic ingredients or their by-products in wastewater treatment processes is needed to allow development of recycle/reuse water quality criteria.

3) The technical and economical feasibility of field wastewater treatment processes for recycle/reuse purposes should be determined based on acceptable health criteria.

4) Data should be obtained on the effectiveness of wastewater treatment processes to remove NBC contaminants.

5) The reliability of wastewater treatment processes and monitoring equipment operated under field conditions and their ability to meet water quality requirements for non-potable reuse should be determined.

6) Methods for safe and effective disposal of concentrated waste products from treatment processes should be developed.

D. DETECTION AND ANALYSIS OF WATER CONTAMINATION

Introduction

To determine water quality, analyses must be performed for potential contaminants and/or indicators of water quality. These contaminants/indicators are grouped into three major topics:

1) environmental background pathogens and inorganic salts,
2) industrial pollutants such as pesticides
3) NBC agents.

The bacteriological quality of water is determined indirectly by testing for an indicator, residual chlorine. The inorganic salts of interest are directly measured. No routine analysis procedures are specified by the Army test for industrial pollutants. The NBC detection and analysis methods include detection of classes as well as analysis of individual agents. The chlorine kits and Water Quality Analysis Sets focus on the measurement of environmental background contamination. The focus of the NBC and industrial pollutant measurement situations are self-evident.

One aspect of evaluating the effectiveness of detection and analysis equipment serves to accent another related research need. The performance rating of detection and analysis equipment is based on the capability to measure contamination levels specified by the Army (maximum permissible concentration criteria). Therefore, the performance and development needs of the detection/analysis equipment is dependent on the adequacy of existing water quality criteria.

Many of the existing tests were designed for operation at about 70°F and their accuracy and reliability may be inadequate in extreme hot or cold environments. A further concern is associated with operation in a hot climate which is likely to cause accelerated deterioration of test reagents.

1. TOPIC: Analyses for Total and Free Chlorine Residual in Treated Water

Situation: Operational Environment - All
Operational Characteristics - All

REQUIREMENTS

Criteria:

1) Measurement kit and procedure must be suitable for field use.

2) Accurately measure free available chlorine levels (FAC) in the concentration range of 0.1 to 10 mg/l (TB MED 229).[1]

3) Accurately measure total chlorine levels in the concentration range 2 to 10 mg/l.

4) Method must not be susceptible to interference by chemical species commonly found in water supplies.

Equipment:

1) Water Quality Analysis set, Engineer NSN 6630-00-140-7820

2) Field Chlorination Kit - FSN 6630-00-087-1838, Fed. Spec. O-C-289.

Procedure:

1) Chlorine Comparator, Water Quality Control Set, Reconnaissance and Routine Control[2].

A tube filled with water sample is placed in a handheld color comparator, and a dropper of diethyl p-phenylene diamine (DPD) is added.* [Diethyl-p-phenylene diamine has replaced the orthotolidine-sodium arsenite (OTA) reagents formerly in the kit[4] but the method is essentially the same.] Using the chlorine color comparator disc in the color comparator, the sample color is matched with the color disc and the concentration of free available chlorine is read in units of mg/l. The measurement range is 0.1 to 10 mg/l free chlorine.

2) Field Chlorination Kit (FM 21-10)[3]

A test tube labeled with the residual chlorine concentration specified (Range 2, 5 and 10 mg) is selected. One DPD tablet is added to the tube filled with a sample of water to just below the yellow band level. The tube is capped and shaken until the tablet is dissolved. Its color is compared to the color of the test tube band.

If the solution is same shade or darker than band, then the chlorine residual is equal to or greater than chlorine concentration in the test tube. If the solution is colorless or lighter in shade than the test tube band, then water does not contain a sufficient chlorine residual. (The method is capable only of measuring total chlorine residual.)

Effectiveness:

1) Total chlorine residual is adequately measured and this parameter indicates that the bacterial quality of water meets water potability criteria.

2) The field chlorination kit using the OTA Method cannot measure free available chlorine (FAC) and cannot test for TB Med 229 specification for FAC. Natick R&D Laboratories are presently modifying the kit to measure FAC, using DPD reagent.

b) The Chlorine Comparator in the Water Quality Control Set (TM 5-700) measures free available chlorine (FAC) levels in the range of 0.1 to 10 mg/l, but the DPD (and OTA) reagents yield false positive FAC levels for water containing high levels of combined chlorine residual[4], manganese, or chromium ions. Therefore, the method cannot reliably test for TB MED 229 specification for FAC, when interferring ions are present.

Field Experience:

1) Water point operators were not adequately trained to measure free available concentrations.

2) The necessary solutions for free available chlorine determination were not available to water point operators.

3) The procedure for the residual chlorine test using the test kit contained in the Field Chlorination Kit was easily understood.

4) The color bands on the Field Chlorination Kit test tubes may be discolored and thus of little value.

Alternatives:

1) A modified DPD test has been developed and experimentally tested, which improves the results of the free available chlorine test but does not eliminate the interference effects entirely.[6]

2) A new procedure (FACTS) to determine free available chlorine levels has been tested using syringaldazine that is not susceptible to interference by combined chlorine residuals.[4]

3) A Bio FAC procedure which accurately measures free available chlorine levels in the presence of colorimetric measurement interferences has been reported. It is apparently unaffected by the presence of combined chlorine residuals.[4]

POTENTIAL HEALTH EFFECTS

Inadequate free available chlorine residual in water containing:

a) Protozoan cyst or bacterial spore contamination - see Section III C, Topic 1.

b) Virus contamination, i.e., hepatitis - see Section III C, Topic 1.

c) Protected or resistant agents, i.e., coated, micro-encapsulated or genetically engineered.

DOCUMENTATION*

1) TB Med 229. "Sanitary Control and Surveillance of Water Supplies at Fixed and Field Installations," 29 August 1975.[f]

2) TM 5-700. Field Water Supply, July 1967.[f]

3) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

4) FACT SHEET (undated, unsigned, may have originated with Natick R&D Command).[e]

5) Benefield, R.O., LTC, "Water Supply in the Republic of Vietnam, Army Concept Team in Vietnam, Project No. ACL-22F, 118 pgs, 1967, AD825260.[a]

6) Palin, A.T., "Analytic Note: A New DPD-Steadifac Method for Specific Determination of Free Available Chlorine in the Presence of High Monochlorine," JAWA, 121-122, Feb. 1980.

7) Memorandum: Subject: Army Field Chlorine Determination Procedures; Current Shortcomings and Potential Future Improvements. Dept. of Army, Washington, D.C. (undated and unsigned).[e]

DATA GAPS AND RESEARCH NEEDS

1) Field Chlorination Kit FSN 6850-270-6225, Fed. Spec. O-C-289 should contain a test kit for free available chlorine (FAC) if TB MED 229 criteria for residual FAC are to be met. (The kit has recently been modified by Natick R&D Laboratories to include FAC test capability.)

2) Approved methods currently in use to determine FAC are susceptible to interferences. The alternatives should be evaluated for use by the Army as approved methods.[4,7]

3) The current accuracy and precision of the FAC test is not documented. This should be determined and necessary requirements established.

*For explanatory notes a-g, see page 186.

TOPIC 2: Routine Water Quality Analyses

Situation: Operational Environment - All
Operational Characteristics - All

REQUIREMENTS

Criteria[1]:

1) The Water Quality Analysis Set Engineer (EN) must be able to analyze raw and treated water for general physical characteristics such as turbidity, color, pH, alkalinity, sulfate, chloride, chlorine demand, chlorine residuals, hardness, coagulation properties, total dissolved solids, and NBC contamination. The required accuracy and sensitivity of the required measurements are listed in Reference 1.

2) The Water Quality Analysis Set, Preventive Medicine (PM) must be able to detect and analyze: zinc, fluoride, iron, magnesium, ammonia, nitrate, dissolved oxygen, and mineral acidity in addition to the criteria described for the engineering set. Accuracy and sensitivity of the required measurements are listed in Reference 2.

3) The Water Quality Analysis Set, Medical Laboratory (ML) must be able to measure: pH, mineral acidity, barium, cadmium, chromium, cyanide, lead, mercury, ammonia, selenium, sulfate, copper, and all tests specified for the PM set. Accuracy and sensitivity of the required measurements are listed in Reference 1.

Equipment:

1) Water Quality Analysis Set, Engineer. NSN 6630-00-140-7820
The set weighs 55 lbs. Components are listed in Table 13.

2) Water Quality Analysis Set, Preventive Medicine
The set weighs 55 lbs. Components are lsited in Table 14.

3) Water Quality Analysis Set, Medical Laboratory
The ML set is described in Reference 7. It is packaged in 10 cases each weighing from 41 to 142 lbs. A description of the components is given in Reference 1. This list was not type classified for Army use.

Procedure:

1) TM 5-700[2] provides a detailed procedure for the obsolete engineer's set and should be updated.

2) The tests included in the engineering set, preventive medicine set, and medical laboratory set are discussed by Roesch.[1,4]

3) TM 5-6630-215-2 provides detailed procedures for the Engineer and Preventive Medicine Kits[3].

TABLE 13

ENGINEER WATER QUALITY ANALYSIS SET COMPONENTS[4]

(1) Turbidity test kit, Ecologic Instrument corp., Model TTM

(2) Color test kit, Hach Chemical Co., Model CO-1.

(3) Chloride test kit, Hach Chemical Co., Model 7-P.

(4) Sulfate test kit, Taylor Chemical Inc., Catalog No. 1555.

(5) Hardness test kit, Hach Chemical Co., Model HA-4P.

(6) Alkalinity test kit, Taylor Chemical Co., Catalogue No. 1526.

(7) Coagulation test kit, Hach Chemical Co., Model JA-1.

(8) Turbidity-free water kit consisting of a breaker, vacuum flask, filter funnel, filter paper, and suction bulb.

(9) Total dissolved solids meter, Myron L.

(10) Comparator, color FSN 6630-087-1838.

(11) Water testing kit, chemical agents, AN-M2, FSN 6665-171-9747.

(12) Refill kit, chemical agent detector, VG components, FSN 665-909-3547.

TABLE 14

PREVENTIVE MEDICINE WATER QUALITY ANALYSIS SET COMPONENTS[4]

(1) Acidity test kit, Hach Chemical Co., Model AC-5.

(2) Zinc test kit, LaMotte Chemical Products Co., Model ZN.

(3) Multipurpose kit for testing pH, fluoride, iron, ammonia nitrogen, sulfate, and turbidity; Hach Chemical Co. Model DC-DR Colorimeter with various reagents and laboratory glassware..

(4) Dissolved oxygen test kit, LaMotte Chemical Products Co., Model EDO.

(5) Iron test kits, Hach Chemical Co., Models IR-18A and IR-18B.

(6) Acidity test kit, Hach Chemical Co., Model AC-5.

(7) Nitrate-nitrite test kit, Hach Chemical Co., Model NI-10 with pre-treatment kit Model PT-1.

Effectiveness:

1) With the exception of NBC agents, the kit tests are generally sensitive enough to check for field water quality specified in TB MED 229.

2) Neither the engineering nor preventive medicine kit is capable of measuring some raw water quality parameters specified in TB MED 229, for example, barium, cadmium and copper concentrations.

Field Experience:

1) The engineer field testing of the engineer, preventive medicine and medical laboratory sets was conducted in 1973[1,4] Results indicate the turbidity test is not accurately measured by the engineer analysis set method. Turbidity is a parameter used to indicate treatment equipment performance. Users of the preventive medicine kit found the zinc test difficult to interpret. The preventive medicine analysis set users all felt the test directions should be more explicit.

   The magnesium and total dissolved solids test kits were missing from the PM and ML sets. Ammonia and pH analysis equipment was missing from the ML set.

2) Vietnam Experience[5]

   i) Water Quality Control set FSN 6630-262-7288. Engineer set was outdated, poorly packaged, and only the chlorine residual test was being performed at 43 water treatment units evaluated.

   ii) During the early phases of Vietnam experience there were insufficient preventive medicine personnel to test water quality.

Field Interviews:

The new Engineer and Preventive Medicine Kits of the Water Quality Analysis Sets are inadequate. The kits should be re-evaluated with respect to current water treatment equipment and procedures[6].

Most of the reagents, encapsulated or liquid, have too short a shelf life for field use at remote locations[7]. Use of outdated reagents will contribute to inaccuracies.

POTENTIAL HEALTH EFFECTS

1) Possible adverse health effects of heavy metal ingestion (see Section III C, Topic 2).

2) Inaccurate turbidity measurements could lead to consumption of water high in suspended solids containing chlorine-resistant viruses and cysts. (see Section III C, Topic 1).

DOCUMENTATION*

1) Kamenik, P.H., et al., "Development Test II (Engineering Phase) of Water Quality Analysis Sets, Engineer, Preventive Medicine and Medical Laboratory, Final Report," AD 921216, June 1974.

2) TM 5-700. "Field Water Supply," June 1967.[f]

3) TM 5-6630-215-12. Water Quality Analysis Sets, June 1977.[f]

4) Roesch, R.E., "Water Quality Analysis Sets," MERADCOM, Ft. Belvoir, VA, Report 2085, 75 pgs. 1974.

5) Benefield, R.O., LTC, "Water Supply in the Republic of Vietnam," AD825260, 118 pgs. 1967.[a]

6) "Summary of Interview with Personnel at U.S. Army Department of Preventive Medicine, Academy of Health Sciences, Ft. Sam Houston, Texas," 5 November 1980 (Appendix A, 2.1).[b]

7) Telephone Interview with Preventive Medicine Personnel U.S. Army Europe, 15 April 1981. (Appendix A, 3.1)[b]

DATA GAPS AND RESEARCH NEEDS

1) No complete list of approved items for the Water Quality Analysis Sets are available.

2) The current tests are not relevant to the product quality obtained from present water treatment technology. The tests should be re-evaluated based on the current and planned military water treatment methods[6].

3) The training of testing personnel (Engineers and PM personnel) should be improved.[5]

4) Turbidity measurements made in the field with the type classified equipment are not accurate. Improved equipment should be tested and approved.

5) TM 5-700 should be updated to describe the new Engineer Water Quality Analysis Set.

6) State-of-the-art technology for water quality analysis should be evaluated with the objectives of determining which analyses are important and how the procedures and equipment can be adapted for field use.

7) Testing of field water samples from different water sources should be carried out to evaluate the performance (accuracy, sensitivity, etc.) of the water quality analysis kits under various circumstances.

8. The water quality parameters should be examined to determine which of them are <u>essential</u> for measurements in the field.

*For explanatory notes a-g, see page 186.

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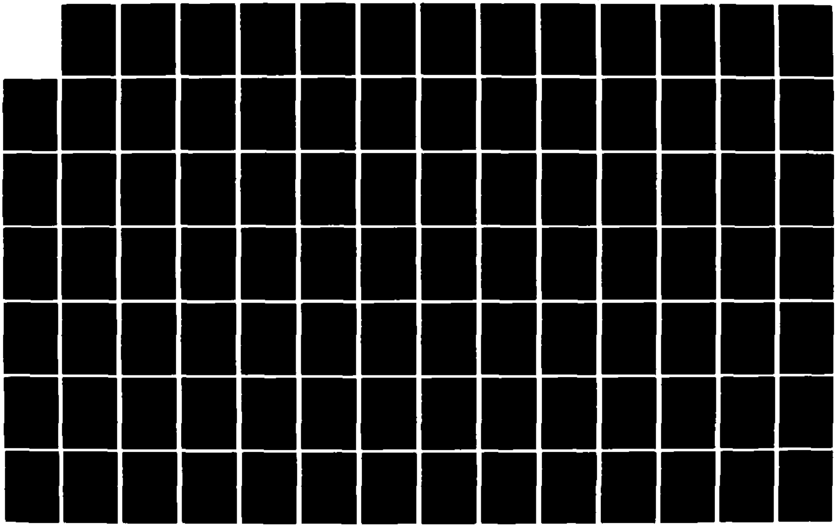

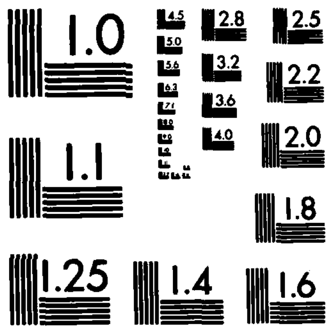

MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS-1963-A

TOPIC 3: Detection and Analyses of Industrial Pollutants in Water

Situation: Operational Environment - All climate/topography, industrial development
Operational Characteristics - All

REQUIREMENTS

Criteria:

1) No official Army doctrine concerning detection and analysis procedures for industrial contamination of water was located during this study, nor were standards for industrial pollutants in water (except for cyanide), located.

2) A test kit for industrial pollutants should be suitable for field use by the Army, able to detect a broad range of industrial pollutants which are potentially hazardous to the health and performance of soldiers, and capable of specific analysis of industrial pollutants of particular concern.

Equipment:

1) No standard test equipment is available for field use by the Army.

2) A kit has been developed by the EPA[1] to detect and analyze target industrial pollutants.

Procedure:

1) No Army doctrine on utilization of industrially polluted water.

2) EPA Kit[1] involves use of a spectrophotometer, pH and conductivity meters, and chromatographic tubes. A well-trained technically oriented individual is needed to perform analyses with this kit.

Effectiveness:

The EPA detection kit is not sufficient to detect acceptable levels of organic pollutants such as DDT, heptachlor, and chlordane (as published in Water Quality Criteria document by the National Academy of Science in 1973 and cited in TB MED 229).

Field Interviews[3]:

A need exists for detection of "opportunity poisons: such as pesticides and hydraulic fluids.

POTENTIAL HEALTH EFFECTS

See Section III C, Topic 2.

DOCUMENTATION*

1) Silvestri, A., et al., "Development of a Kit for Hazardous Material Spills into Waterways," Edgewood Arsenal Special Publication ED-SP-76023, 1976. Department of the Army, Aberdeen Proving Ground, MD 21010.

2) TB MED 229, "Sanitary Control and Surveillance of Water Supplies at Fixed and Field Installations," 29 August 1975.[f]

3) Interview with Personnel at U.S. Army Department of Preventive Medicine, Academy of Health Science, Ft. Sam Houston, Texas, 5 Nov. 1980 (Appendix A. 2.1).[b]

DATA GAPS AND RESEARCH NEEDS

1) The Army should define a list of industrial pollutants (or classes) for which a detection and analysis capability is required.

2) A detection and analysis capability should be developed for those pollutants (or pollutant classes) defined under (1)[3].

3) Non-specific detection of categories of pollutants by small units using simple techniques should be investigated.

4) Commercially available detection and analysis kits for industrial pollutants should be evaluated for potential use by the military.

*For explanatory notes a-g, see page 186.

TOPIC 4: Detection and Analysis of NBC Contamination by a Small Unit in the Field

Situation: Operational Environment - All
Operational Characteristics - Small Unit

REQUIREMENTS

Criteria:

A kit must be capable of detecting threshold effect levels of NBC agents in water.

Equipment:

1) Chemical Agent Detection Refill Kit V-G, ABC-M30, FSN 6665-909-3647

2) Water Testing Kit, Chemical Agents, AN-M2, FSN 6665-171-9747

Procedure:

The equipment available can only be used by specialized personnel who are not typically present in a small field unit. In the absence of specialized personnel and equipment the unit may have to rely on visual indications, e.g., the presence of dead fish, animals, etc.. Unpleasant taste or odor may also be observed in the water.

Effectiveness:

No effective method is currently available to the small unit in the field. It must rely on the simple indications noted above.

Field Interview:

Development of a simple "go or no go" NBC detection for field use is needed.[1,2]

POTENTIAL HEALTH EFFECTS

See Section III C, Topic 3.

DOCUMENTATION*

1) Christians, J.A., "Letter to Dr. Schaub, USAMBRDL," Dept. of the Army, Fort Belvoir, VA, April 1977.[e]

2) Interview with "Combat Developments Directorate, U.S. Army Engineer School, Fort Belvoir, VA," 19 September 1980 (Appendix A, 2.2a).[b]

*For explanatory notes a-g, see page 186.

DATA GAPS AND RESEARCH NEEDS

1) No simple detection method for CW contaminants in water is available for use by small field units. BW contaminants detection must be performed by medical personnel and there is no available field method for measuring RW contaminants in potable water. Research in these areas is needed.

2) Commercially available detection kits which could be adapted for use by small Army units in the field, where specialized personnel may not be available, should be evaluated.

3) A simple detection system sensitive to all identified NBC agents to determine a go/no-go status is needed[2].

4) Criteria are needed to help the small unit leader decide when water is potable, if the possibility of NBC contamination exists.

TOPIC 5: Detection and Analysis of NBC Contamination by Personnel at Water Points

Situation: Operational Environment - All locations
Operational Characteristics - Engineers, P.M., Personnel at Camps and Staging Areas

REQUIREMENTS

Criteria:

A test kit must:

1) Be capable of detecting threshold effect levels of NBC agents in water,

2) Identify and quantify specific agents and/or classes of agents,

3) Be suitable for use by the Army in field conditions.

Equipment:

1) Chemical Agent Water Testing Kit AN-M2 (FSN 6665-171-9747) and Chemical Agent Detector, VG Components Refill Kit ABC-M30-A1(TM 5-700)[1], which are part of the engineer's standard Water Quality Analysis Set. One kit per water purification unit is issued.

2) M19, NBC Agent Sampling and Analysis Kit[1,2,3]. Designed for use by highly trained team including one member with a chemical background.

3) E 56 Chemical Detector Kit in experimental phase[1].

4) A Bioassay test for chemical agents is described by Lindsten.[5]

5) AN/PDR-27 radiac set[1]. One kit per divisional company size combat support unit[4]. Readings obtained by use of this instrument are in units of millirads/hr. and only give an indication that the water contains radioactivity.

6) In development at Chemical Systems Laboratory, XM 272 Kit to replace AN-M2 Kit and the ABC-M30-A1 Kit[6]. The XM-272 CW water test kit is estimated to be at least 4 years to type classification. It is being developed to meet the current TB MED 229 short-term standards for field drinking water. This standard is based on consumption of 5 liters/man/day, in a non-stressful environment.

Procedure:

1) If chemical agents have been employed or are suspected check for:

(a) low pH values
(b) suspicious taste or odor (lacrimating, chlorinous odor, biting taste) or other known characteristic of chemical agents.
(c) excessive chlorine demand.

Test for:

(a) mustard agents (including nitrogen mustard and cyanogen chloride)
(b) nerve agents

2) If the presence of biological agents is suspected, contact field preventive medicine teams or chemical teams for assistance.

3) If radiological contamination is suspected, test water sites using Radiac set AN/PDR-27 for any indication of radiological contamination of the water.

4) If any tests are positive:

(a) seek advice of Army Medical Service personnel
(b) try to find an uncontaminated water source
(c) if a contaminated water source must be used, permission from a medical officer must be granted before treatment begins.

Effectiveness:

1) No kit for the quick determination of biological agents is available.

2) Field measurement of radioactivity contamination in water is qualitative and cannot be directly compared to drinking water standards.

3) The AN-M2 which is a component of the Engineer's Water Quality Analysis Set (WQAS) can detect mustard and arsenic but not VX or GF chemical agents in raw (unchlorinated) water. It can only detect arsenic in chlorinated waters. (Mustard agents are destroyed by chlorine, therefore, the test is not important for adequately chlorinated water[5].)

Addition of ABC-M30-Al kit to the set provides the capability to detect V and G agents in both unchlorinated and chlorinated water. (It does not distinguish between V and G agents.) The availability and use of the ABC-M30-Al kit in the WQAS is not described in TM 5-700. Neither kit is adequate to detect cyanogen chloride in chlorinated water. Data on the detection levels for field use of the WQAS kits are not available but the accuracy is suspect and should only be used as a rough indicator of maximum permissible concentration levels of chemical agents in water[5].

4) The Ml9 kit is capable of measuring a broad range of chemical agents. The sensitivity of some tests such as nerve agent detection are not sufficient to ensure that standards cited in TB MED 229 are met

(TM 3-6665-205-10/2). Although TM 5-700 mentions the use of the M19 kit, the manual procedure appears more applicable to the AN-M2 kit.

5) ABC-M8 VGH chemical agent detector paper is provided with the M19 kit. Water can be qualitatively checked quickly for V, G or H agents with these papers.

6) XM 272 will replace the AN-M2 Water Testing and Screening Kit and the ABC-M30-A1 Refill Kit, Chemical Agent Detector V-G. The XM 272 kit should be capable of measuring the current sensitivity standard for mustard agents and have the capability to test for the blood agents. It will detect CW agents in raw and treated water (5 to 10 mg/l free available chlorine residual) on a go-no-go basis at the MPC values specified in TB MED 229 for short-term use.

Field Interview:[6]

The development of the XM-272 detection kit will be complete in about four years. It will be able to measure levels specified in TB MED 229, but a more stringent standard would necessitate redeveloping the kit.

POTENTIAL HEALTH EFFECTS

See Section III C, Topic 4.

DOCUMENTATION*

1) TM 5-700. "Field Water Supply," July 1967.[f]

2) TM 3-6665-205-10/1. "Operator's Manual, Sampling and Analyzing Kit, CBR Agent M19," Sept. 1966.[f]

3) TM 3-6665-205-10/2. "Operator's Manual, Sampling and Analyzing Kit CBR Agent," Sept. 1966.[f]

4) FM 21-40. "NBC Defense," 14 Oct. 1977.[f]

5) Lindsten, D.C., Schmitt, R.P., "Decontamination of Water Containing Chemical Warfare Agents," MERADCOM, Ft. Belvoir, VA, 22060, Rept. 2125, 101 pgs, January 1975.

6) Interview with Personnel at DOD, Office of the Surgeon General, Feb. 3, 1981 (Appendix A, 4.6).[b]

7) Gensler, J., LTC, "Subject: Special Working Party on the Minimum Requirements for Water Potability in the Field (SWP/MRWP); SGRD-UBG, USAMBRDL, Ft. Detrick, MD, 4 Dec. 1980.[e]

*For explanatory notes a-g, see page 186.

8) Albertson, J.N., Col., "Subject: Field Drinking Water Policy and Operational Capability Oversights," SGRD-UBG, USAMBRDL, Ft. Detrick, MD.[e]

9) Kastenmeyer, W.W., Col., "Subject: Field Drinking Water Standards for CW Agents,: DRDAR-CL, Chemical Systems Lab., Aberdeen Proving Ground, MD, 28 Nov. 1980.

DATA GAPS AND RESEARCH NEEDS

1) The water quality criteria for NBC agents should be re-evaluated particularly for enhanced consumption situations[7,8,9]. Subsequently, the detection and analysis needs should be redefined and the necessary capability developed. The parallel development of water quality criteria and detection/analysis capabilities can lead to serious problems. For example, the XM 272 kit is now being developed on the basis of standards defined in TB MED 229. If the former standards are made more stringent the XM 272 may have to be developed[6].

2) There is no biological agent detection kit for field use. Potential methods should be evaluated.

3) There is no appropriate quantitative method to measure radiological contamination of water in the field. Potential methods should be evaluated.

4) The sensitivity and accuracy of the AN-M2 and ABC-M30-Al chemical agent detector kit should be specified.

5) The feasibility of modifying the experimental XM-272 kit to allow testing for chemical agents under a variety of field conditions should be determined.

6) The sensitivity of the M19 kit is not sufficient to adequately test for some agents. It should be improved.

7) Sensitivity and accuracy of field CW detection kits with respect to long-term consumption standards should be determined.

8) A simple yes/no detection kit with appropriate sensitivity is needed for field use.

9) The feasibility of biological indicators should be evaluated.

10) TM 5-700 should be updated to include the addition of ABC-M30-Al kit for detecting V and G agents to the Water Quality Analysis Set.

11) The effects of various impurities in water on agent detection capability (sensitivity and precision, etc.) needs to be established. Specific problem impurities should be identified.

12) The adequacy of trained personnel to respond to a major use by enemy forces of NBC agents as a tactical weapon should be determined. If training is not adequate, an appropriate training program should be developed.

E. WATER TREATMENT

Introduction

Discussion of the water field expedient treatment methods practiced by the Army is divided into methods available to:

- individuals,
- small units, and
- company-size forces or larger.

The treatment of water contaminated with chemical and/or biological agents is addressed as a separate topic. Disinfection is the standard treatment used by the individual and the small unit in the field. The former uses iodine and the latter chlorine as a disinfecting agent. The water treatment methods utilized at camps or water distribution points include:

- ERDLator Treatment
- Reverse Osmosis Water Purification Units (ROWPU)
- Vapor Compression Distillation

Any pretreatment required is related to the method of water treatment being employed and the quality of raw water. Therefore, pretreatment is discussed within the framework of individual topics, except for CW-BW pretreatment.

Each topic considers the performance of the water treatment under different climatic conditions and with varying raw water quality. The ability of each method to produce acceptable potable water (as defined by TB MED 229) is discussed. Effectiveness of the treatment methods and equipment in terms of the Army's need for high reliability, low maintenance, easy transportation and straightforward operation is considered.

TOPIC 1: Treatment of Drinking Water - Individual Soldier

Situation: *Operational Environment - All Environments*
Operational Characteristics - Individual Soldier in the Field

REQUIREMENTS

Criteria for a disinfectant to treat drinking water in the field (DMS-A 925/29)[1] are:

1) Effective and simple to use
2) Acceptable to the user
3) Safe for extended use
4) Suitable packaging and providing a long shelf life
5) Economical

The approved disinfectant for the individual soldier in the field is the water treatment tablet based on iodine.[4] Its composition is given below:

- 19.1 - 21.3 mg. Globaline $(NH_2CH_2COOH)_4 \bullet HI \bullet 1.25\ I_2$,
- 82.5 - 92.3 mg. Disodium salt of pyrophosphoric acid $(Na_2H_2P_2O_7)$,
- not more than 6 mg. talc[2].

Dosage:

One tablet per quart canteen for clear water (FM-21-10)[3].
Two tablets per quart canteen for (cold or) cloudy water (FM-21-10)[3].
(Three tablets per quart canteen for muddy water[5]).

Dose should be doubled for two quart canteen (FM-21-10).

Procedure: (presented in FM-21-10[3])

1) Check the physical condition of iodine tablet. Do not use tablets which are not a steel grey color, stick together, or crumble.

2) Fill the canteen with the cleanest water available.

3) Add one iodine tablet per quart capacity of canteen for clear water, two tablets per quart canteen capacity for cloudy water, and place cup loosely on canteen. After 5 minutes, shake canteen well, tighten canteen cap and then wait an additional 20 minutes before using water.

Effectiveness:

This disinfection treatment provides sufficient sterilizing action to kill important natural biological contaminants. Treatment is not sufficient to decontaminate water contaminated with NBC agents. The rate of disinfection is fast and the 25 minute waiting period described in FM-21-10 is an adequate disinfection time at 5°C. The disinfection reaction is quicker at higher temperature.

Field Experience:

1) Soldiers in Vietnam did not recognize the signs of physical deterioration of iodine tablets such as color change[5].

2) Soldiers have complained of an unpleasant taste associated with the use of iodine. However, it was not clear whether the objectionable taste was a function of the iodine tablets or the quality of the raw water.

3) Soldiers in Vietnam added soft drink mix to their drinking water to improve its taste. Flavoring agents containing ascorbic acid (Vitamin C) destroy the disinfection capability of the iodine tablet if the flavoring is added prior to or simultaneously with the iodine tablets. If the flavoring agent is added after the disinfection period of twenty-five minutes, the free residual iodine will be destroyed and recontamination will be possible.

Field Interview[6]:

Iodine tablets provide adequate disinfection capability except for water contaminated with NBC agents. The individual soldier or small unit needs some removal capability for NBC agents and industrial pollutants.

Puritabs, an alternative disinfectant is being used by some NATO countries. It has not been fully tested by the U.S. Army and is not approved for use.[2]

An alternative method of disinfection is to boil the water.[3] Calcium hypochlorite may be useable as an alternative disinfectant.

The presently used iodine tablet is accepted as the best disinfectant for treatment of an individual's water supply in the field.

POTENTIAL HEALTH EFFECTS

1) For ineffectively treated raw water, see Section III C, Topics 1 and 2.

2) NBC Contaminated Water (See Section III C, Topic 3).

3) Symptoms of excess iodine uptake are: sore or dry throat, running eyes and nose, saliva secretion, skin eruption[1]

4) Dehydration due to poor palatability of water (see Section III C, Topic 4).

DOCUMENTATION*

1) Lynam, D.F., "AFFSE Water Sterilizing Tablets," DMS-A 925/79, December 10, 1979.[e]

2) Rodgers, M.R., et al., "Military Individual and Small Group Water Disinfecting Systems: An Assessment," Military Medicine, 14(4):268-277, 1977.

3) FM-21-10. "Field Hygiene and Sanitation," July 1970.[f]

4) "Military Specification Water Purification Tablet, Iodine", Mil-W-2836, 18 December 1979.[e]

5) Benefield, R.O., LTC, "Water Supply in the Republic of Vietnam," AD 825260,[a] 1967.

6) Field Interview with personnel at U.S. Army Natick R&D Laboratory, Natick, MA, 11 December 1980. (Appendix A, 1.6)[b]

7) Rodgers, M., Kaplan, A., "Feasibility Study of a Filtration Unit for the Removal by the Individual of CBR Agents from Water," Tech. Report, CP-19, Quartermaster Rech. & Engr. Ctr., Natick, MA (1961).

DATA GAPS AND RESEARCH NEEDS

1) The feasibility of detection kits for NBC agents and other pollutants not removed by iodine tablet treatment should be investigated.

2) Short term effects of excess iodine should be determined, particularly in relation to increased water consumption necessary in hot arid climates.

3) A flavoring agent which does not interfere with the iodine disinfection capability should be sought.

4) The potential for reinfection of treated water which contains no residual iodine should be defined.

5) The possibility of an indicator for residual iodine (such as starch/iodine paper) to be used in the field should be considered.

6) A study[7] concluded that a small filtration unit for the individual soldier to remove NBC contaminants from water was feasible. Further consideration should be given to the developments of such a filter.[6]

7) The influence of the taste of the untreated water on the ability of soldiers to consume sufficient quantities of iodine treated water should be investigated.

*For explanatory notes a-g, see page 186.

8) Multiple strip packaging of iodine tablets, each containing a small number of tablets, should be further investigated given the fact that tablets in opened vials are susceptible to deterioration.

TOPIC 2. Treatment of Drinking Water - Small Unit

Situation *Operational Environment - All*
Operational Characteristics - Small Unit in the Field

REQUIREMENTS

Criteria for field use disinfectant for drinking water (DMS-A 925/79)[1]:

1) Effective and simple to use

2) Acceptable to the user

3) Safe for extended use

4) Suitable packaging and a long shelf life

5) Economical

Equipment:

1) Lyster bag: 30-gallon capacity, allows evaporative cooling, issue one per 100 men.[2]

2) Knapsack filter unit (FSN 4610-256-4198): 1/4 gallon per minute capacity, weight 7 lbs., disposable filters, capable of filtering 5 gallons of muddy water before clogging (FM 21-10)[3]. (not standard issue)

3) Disinfectant kit: chlorination ampoules, residual chlorine analysis set (FM 21-10).[3]

Disinfectant: Chlorine

Composition: Calcium hypochlorite ($Ca(OCl)_2$), .5 gram/ampoule

Procedure:[2,4]

1) Filtration to remove solids improves taste (optional).

2) Fill Lyster bag with cleanest water available.

3) Add 3 ampoules of calcium hypochlorite.

4) After 10 minutes, check the total residual chlorine level with the residual chlorine color comparison kit. If the chlorine residual concentration is below the prescribed level of 5 mg/l, add more calcium hypochlorite.

5) Allow a total contact time of 30 minutes with a 5 mg/l chlorine residual before use in hot weather and 60 minutes in cold weather (40°F).

Effectiveness:

The following six variables identified in TB MED 229[4] affect the sterilizing capacity of chlorine:

1) Type and concentration of chlorine residuals (i.e., free vs. combined chlorine) available.

2) pH of water,

3) Type, density or organisms and resistance to chlorine,

4) Contact time,

5) Temperature of water,

6) Concentration of chlorine demanding substances.

Chlorine is effective in destroying most bacteria (but not bacterial spores). Only small residual concentrations, (0.2 mg/l free available chlorine[4]) are necessary to ensure vegatative bacterial destruction. Protozoan cysts and viruses, *infectious hepatitis, entamoeba hystolitica* are more resistant and require free available chlorine residuals of 10 mg/l in cold weather and levels of 2, 5, 10 mg/l at pH 6, 7 and 8 respectively in hot weather, if contamination is suspected[4]. Rodgers (1977)[5] recommends that with cold, raw water pH≥8, and/or presence of large amounts of organic materials, a total residual chlorine concentration of 10 mg/l should be maintained. This disinfection procedure may destroy some chemical and/or biological agents, but is not sufficient to decontaminate water contaminated with NBC agents.[6]

The effectiveness of the Lyster bag to keep water cool in hot, arid climates is not documented. In cold dry climates, freezing problems are to be expected.

The knapsack filtering device is effective in clarifying water and will increase the palatability of dirty water. It can remove some insoluble radioactive particles, but is not sufficient to decontaminate water which is contaminated with soluble radiological agents. [This item has been classified non-standard and is no longer available.]

Field Experience:[7,8]

1) Knapsack filter units were not used in Vietnam. Many small unit commanders did not know the knapsack filter unit existed and preferred aerial resupply anyway.

2) In Vietnam, 32-gallon galvanized iron (GI) cans were used more often than Lyster bags.

3) In Vietnam, the team medical specialist was in charge of chlorination of field water supplies. Total residual chlorine test kits were found at all sites investigated in the study[7] except one at which the medic added a fixed dose he considered sufficient. In all cases, the total chlorine residual was found to be 5 mg/l except where the specified level was 2 mg/l.

4) In cold regions an insulated 5 gallon food container is preferred for water supply.

POTENTIAL HEALTH EFFECTS

1) Ineffectively treated raw water (See Section III C, Topic 2).

2) NBC contaminated water (See Section III C, Topic 4).

3) Dehydration due to poor palatability of water (see Section III B, Topic 2).

DOCUMENTATION*

1) Lynam, D.F., "AFFSE Water Sterilizing Tablets," DMS-A 925/79, 10 December 1979.[e]

2) Academy of Health Sciences, Preventive Medicine Div., "Field Water Supply and Waste Disposal," 2 hr. course for AMEDD Officer Basic and AMEDD Officer Orientation, LP73-430-124-030.[e]

3) FM 21-10. "Field Hygiene and Sanitation," July 1970.[f]

4) TB MED 229. "Sanitary Control and Surveillance of Water Supplies at Fixed and Field Installations," August 1975.[f]

5) Rodgers, M.R., et al., "Military Individual and Small Group Water Disinfecting Systems: An Assessment," Military Med. 141(4):268-277, (1977).

6) Cavendish, P.B., "Procedures for the Treatment, Acceptability and Provision of Potable Water in the Field," Standardization Agreement of NATO, STANAG No. 285, 22 Jan 1979.[e]

7) Benefield, R.O., LTC, Arty, "Water Supply in the Republic of Vietnam," AD #825260,[a] 118 pgs. (1967).

8) Alter, A.J., "Water Supply in Cold Regions," January 1969, Cold Regions Research and Engineering Laboratory, Hanover, N.H., AD 685850.[a]

*For explanatory notes a-g, see page 186.

9) Field interview with personnel at U.S. Army Natick R&D Laboratory, Natick, MA, 11 December 1980. (Appendix A, 1.6)[b]

10) Rodgers, M., and Kaplan, A., "Feasibility Study of a Filtration Unit for the Removal by the Individual of CBR Agents from Water," Tech. Report, CP-19, Quartermaster Rsch. & Engr. Ctr., Natick, MA (1961).

DATA GAPS AND RESEARCH NEEDS

1) Technical requirements for individuals or small groups to clarify their own water should be evaluated.

2) The potential for viral species, resistant to chlorination, to affect soldiers should be defined.

3) The use and benefit of a detection kit for both free available and total residual chlorine concentration should be investigated.

4) The potential for interference with the current colorimetric test for residual chlorine and the identification and development of secondary detection methods (i.e., taste, smell) should be investigated.

5) Detection kits for debilitating agents (e.g., cysts, NBC agents) not removed by approved chlorination should be designed for field use.

6) There appear to be conflicting recommendations between references 2 and 4 on acceptable levels of free chlorine. This conflict should be resolved.

7) Tests should be made to determine which flavoring agents interfere with chlorine disinfection or maintenance of a chlorine residual.

8) The consumption rate of field chlorinated raw water by soldiers compared to more palatable sources should be investigated.

9) The water loss rate of a Lyster bag in a hot arid region due to evaporation should be determined as a function of temperature, humidity and the variability of individual units.

10) Requirements for removal of NBC contaminants at distribution points when using equipment such as the Lyster bag should be determined.

TOPIC 3 : ERDlator Treatment Units

Situation: *Operational Environment - All (especially temperate & tropical)*
Operational Characteristics - Company and Larger Units

REQUIREMENTS

Criteria:[1]

1) Produce potable water meeting approved (TB MED 229)[1] standards from fresh water sources.

2) Be suitable for long storage and rapid mobilization.

3) Operate 20 hours per day with one man/shift.

4) Be transportable by military vehicles including air delivery.

5) Operate in tropic, arid, and subfreezing environments.

6) Be self-contained with operating expendables for 100 hrs. and own engine generator set.

Equipment:

The following equipment is available.

1) 420 GPH ERDLator can be delivered by helicopter or parachute.

2) 1500 GPH ERDLator, truck mounted[2]

3) 3000 GPH ERDLator, truck and base mounted[3,4]

4) 10,000 GPH ERDLator, semi-permanent installation.

Operation:

The ERDLator unit includes: water pumps, chemical feeders for coagulation upflow basin diatomite filters, chlorinator, electric generator and equipment for potable water storage and distribution. The units are all transportable and capable of being made operational within one hour.

Raw water is drawn into the ERDlator tank which serves as a mixer and a clarifier. The flow is designed to provide a rotary motion for mixing of the water treatment chemicals (ferric chloride, powdered limestone and calcium hypochlorite). Water flows down the inner concentric compartment and into the outer compartment where its velocity is reduced and separation of the slurry and contaminants occurs. The slurry is transferred to the sludge concentrator and clear water is drawn off the top of the outer compartment. Suspended matter is further reduced by filtration through a diatomite filter.

Effectiveness:

1) Will produce clean, disinfected water from fresh water sources.

2) Will not remove soluble salts, i.e., cannot desalt brackish or sea water.

3) Will not reduce soluble chemical or nuclear agents to meet drinking water criteria without auxiliary equipment.

Field Experience:[5]

1) Chemical feeders, electrical components and pump seals are high mortality items.

2) It is difficult to determine optimum coagulant dosages for the variable quality of surface water sources found in the field.

3) It is difficult to coagulate cold water saturated with dissolved gases because the bubbles released hinder sedimentation and most of the coagulated material is transferred to the filters.

POTENTIAL HEALTH EFFECTS

1) Water sources containing excessive soluble salts causing gastric illness are not removed by the ERDLator treatment process.

2) Standard ERDlator treatment is not sufficient to remove all NBC agents (see Section III E, Topic 6, for pretreatment to remove chemical and biological agents) and injestion of the treated water containing NBC agents may cause incapacity or casualty.

DOCUMENTATION*

1) TB MED 229. "Sanitary Control and Surveillance of Water Supplies at Fixed and Field Installations," August 1965.[f]

2) TM 5-4610-204-20P. "Water Purification Unit, FSN 4610-649-8386," Oct. 1980.[f]

3) TM 5-4610-205-10. "Water Purification Unit, FSN 4610-857-0330," August 1963.[f]

4) TM 5-4610-223-15. "Water Purification Unit, FSN 4610-168-1799," September 1969.[f]

5) Benefield, R.O., "Water Supply in the Republic of Vietnam," AD 825260,[a] 119 pgs (1967).

*For explanatory notes a-g, see page 186.

DATA GAPS AND RESEARCH NEEDS

1) Possible substitutes for chlorine used as disinfecting and oxidizing agents in the coagulation process should be investigated.

2) Potential deterioration of calcium hypochlorite disinfectant under hot humid conditions should be investigated.

TOPIC 4: Reverse Osmosis Water Purification Unit (ROWPU)

Situation: *Operational Environment - All (especially Arid Climate, Coastal Region)*
Operational Characteristics - Company Size and Larger Units

REQUIREMENTS

Criteria:[1]

1) Produce potable water from fresh, brackish and seawater source to meet field water standards of TB MED 229.

2) Remove NBC contaminants to acceptable drinking water levels.

3) Be suitable for long storage and rapid mobilization.

4) Operate 20 hours per day with one man/shift.

5) Be transportable on standard military vehicles, including air delivery.

Equipment:[2,7]

1) 600 GPH+ Trailer Mounted ROWPU (i.e., 600 GPH potable water product)

2) 2000/3000 GPH Trailer Mounted ROWPU (planned but not yet in current inventory)

ROWPU's include water pumps, chemical feed pumps, pretreatment filters, throwaway cartridge filters, high pressure pump, reverse osmosis modules, engine generator and equipment for storage and distribution of potable water. The membranes are poly (ether urea) as spiral wound modules. They are wet-dry reversible.[6]

Raw water is treated with a cationic polyelectrolyte and then undergoes multi-media filtration. It is pumped at high pressure (800 psi) past the RO membrane and about 50% of the input water passes through the membrane to give a potable product. The contaminated brine which remains is discarded.

Effectiveness:[2,3]

1) The developed trailer mounted model produces 600 GPH from brackish water sources and 400 GPH from seawater.

2) A potential exists for membrane pinholes to allow passage of soluble salts, virus or other contaminants. No analytical procedures presently exist to detect these pinholes, except for conductivity measurements which may be inadequate in low conductivity water.

3) Typically 50% of the brackish water influent or 33% of salt water influent is recovered as product potable water.

4) NBC levels in the influent are greatly reduced by RO treatment but effluent levels may exceed established safe concentrations (MPC) depending on initial concentration. Additional post-treatment with carbon filters and/or ion exchange is capable of further reducing NBC concentrations to achieve safe levels.[5]

5) Water sources with high turbidity (100 ppm) necessitate excessive backwashing of the multi-media filter to prevent fouling of the RO membranes.

6) Membranes are degraded at temperatures above 45°C, at pressures exceeding 850 psi and by chlorine residuals above 1 ppm. (Cellulose acetate membranes are resistant to chlorine, but cannot produce potable water from seawater in a single pass [8].)

Field Experience:[3]

1) During field testing, shortcomings were found in the operating and maintenance manual and training instructions. The New Equipment Training at MERADCOM has been initiated as corrective action.

   Based on the Failure Scoring Conference and TECOM Independent Evaluation, the mean time between failure for the 600 GPH ROWPU is 248 hours with 91% confidence when operated with a standard A generator.[7]

   Operational availability was 91.4%.

2) Water test kits for manganese and iron are essential because these metals foul the membrane.

POTENTIAL HEALTH EFFECTS

1. Incapacity or casualty from drinking inadequately treated water.

2. Dehydration from water shortage if ROWPU units do not meet the rated output. (N.B. output with seawater is only 67% of the rated output for brackish water)

DOCUMENTATION*

1) "Required Operational Capability for a Family of Water Supply Equipment," March 1974, Headquarters TRADOC, Fort Monroe, VA.

2) Schmitt, R.P., "Military Requirements for Water Supply," reprinted by Hydranautics Water System, Goleta, California, presented at: First Desalination Conference on the American Continent, October 1976.[e]

*For explanatory notes a-g, see page 186.

3) Carnahan, R.P., et al., "Treatment of Brackish Sea and Chemically Contaminated Fresh Water by Reverse Osmosis," MERADCOM, Ft. Belvoir, VA.[e]

4) Schmitt, R.P., "Reverse Osmosis and Future Army Water Supply," ASME publication, 8 pages (1974).

5) Lindsten, D.C., and P.R. DesRoches, "Decontamination of Water Containing Chemical and Radiological Warfare Agencts by Reverse Osmosis," MERADCOM Report #2211, AD AO46203,[a] June 1977.

6) Information Paper, "Reverse Osmosis Technology for the Army." DRDME-GS, 18 March 1981.

7) Lindsten, D.C., "3000/2000 GPH Reverse Osmosis Water Purification Unit", MFR N°15, October 12, 1979. MERADCOM, Ft. Belvoir, VA.

8) Commercial Literature, Fluid Systems Division, UOP, Inc., San Diego, CA.

DATA GAPS AND RESEARCH NEEDS

1) The effectiveness of the ROWPU equipment for removing NBC agents needs further evaluation. The potential risk of breakthrough of residual NBC agents after operating with agent contaminated water needs to be defined.

2) Capability of the ROWPU to treat already chlorinated water needs to be defined and further developed.

3) An alternative method to detect membrane leakage in low conductivity water should be developed.

4) Alternatives disinfectants which would not degrade membrane performance should be investigated.

5) More effective filtration for microorganisms should be developed.

6) A simple field method (colorimetric?) to measure the pH of seawater sl:culd be developed.

TOPIC 5: Vapor Compression Distillation Treatment Unit

Situation: *Operational Environment - Arid and Coastal Regions*
Operational Characteristics - Company Size and Larger Units

REQUIREMENTS

Criteria:[1]

1) Produce potable water from seawater, to meet approved TB MED 229 standards.

2) Be suitable for long storage and rapid mobilization.

3) Be transportable by military vehicles.

Equipment:[2]

1) 150 GPH Vapor Compression Distillation Unit, trailer mounted. Military has only 10 units in depot supply in semi-operational condition. The Navy (CEL) has tested a commercially available, 35 GPH, portable desalination unit[3].

Effectiveness:

1) It can reduce salt content of seawater to acceptable drinking water level.

2) It requires 1 gallon of fuel to produce 100 gallons of drinking water.

3) Not more than 50% of influent is recovered as drinking water.

4) The equipment is ineffective with brackish water sources containing calcium sulfate due to scaling problems.

5) Some volatile chemical contaminants may be entrained with the distillate.

6) It is relatively simple to operate.

Field Experience:

1) Mechanical problems of the engine compressor and heat exchanger make it difficult to maintain operation.

2) Problems of scale and corrosion on heat transfer surfaces have been observed.

POTENTIAL HEALTH EFFECTS

1) Contamination of product water through entrainment and leaks, which may produce incapacitating illness or casualties.

DOCUMENTATION*

1) TB MED 229, "Sanitary Control and Surveillance of Water Supplies at Fixed and Field Installations," August 1975.[f]

2) Gould, P., "Water Supply and Distribution Equipment for the Rapid Deployment Force, " March, 1980, Inst. for Defense Analyses, Paper P-1487, Alexandria, VA.

3) King, J.C., "Evaluation of a 35 GPH Portable Desalination Plant and Conceptual Design of a 220 GPH Containerized Plant," U.S. Naval Facilities Engineering Command, ADA004928,[a] January 1975.

DATA GAPS AND RESEARCH NEEDS

1) Equipment which uses lightweight materials resistant to seawater corrosion should be evaluated (Some aluminum units are in commercial operation).

2) Equipment with improved thermodynamic efficiency should be evaluated.

3) Better methods for prevention and/or removal of scale deposits from heat transfer surfaces need to be developed and/or documented.

*For explanatory notes a-g, see page 186.

TOPIC 6: Water Treatment - Chemical and Biological Agent, Decontamination Pretreatment Unit

Situation: *Operational Environment - All, Water Contaminated by CB Agents*
Operational Characteristics - Company Size and Larger Units

REQUIREMENTS

Criteria:

1) Reduce water soluble chemical and biological warfare agents contamination to acceptable drinking water levels.

2) Be compatible, as a pretreatment process, with the ERDlator water purification units.

3) Operate 20 hour per day with 1 operator/shift.

4) Be transportable by military vehicles.

Equipment:[1,2]

420/3000 GPH CW-BW Water Pretreatment Equipment Set (FSN 4610-00-880-0278). The system consists of calcium hypochlorite treatment at 100 ppm, followed by activated powdered carbon treatment at 600 ppm, then processing of the water in a standard ERDlator unit. (The standard ERDlator unit will remove suspended radiological agents, post treatment by ion-exchange will remove soluble radiological agents). The pretreatment water decontamination unit may become obsolete when ROWPU units are available.

Effectiveness:[1,2]

1) Will inactivate or reduce chemical and biological agents in raw water sources to (short term) levels specified in TB MED 229 if used in conjunction with ERDlator Water Purification.

2) Will operate at variable rates from 420-3000 GPH.

Note: ROWPU treatment appears to be at least as effective for the removal of chemical and radiological agents.

Field Experience:

1) Adding large amounts (15 lbs. to 3000 gallons water) of powdered activated carbon to the pretreatment equipment is difficult in the field.

2) Equipment must be protected by tent shelters from inclement weather conditions.

3) Provision of the expendable supplies (activated carbon and calcium hypochlorite) necessary for the decontamination process may burden the logistics support.

POTENTIAL HEALTH EFFECTS

1) Water inadequately treated to remove BC agents may produce incapacitating illnesses or casualties.

2) Disposal of sludges and equipment are a source of contamination.

DOCUMENTATION*

1) Lindsten, D.C. and R.P. Schmitt, "Decontamination of Water Containing Chemical Warfare Agents," MERADCOM, Fort Belvoir, VA, NTIS: ADA 012630, January 1975.

2) Demek, M., Rosenblatt, D.H., Lindsten, D.C., "Removal of Toxic Chemicals from Water by Reverse Osmosis," Report EATR4356, Edgewood Arsenal, Aberdeen Proving Ground, MD, March 1970.

DATA GAPS AND RESEARCH NEEDS

1) Simple and accurate methods for detection of chemical and biological agents in drinking water supplies need to be developed.

2) Disposal methods for contaminated sludges and decontamination of equipment should be simplified.

3) The equipment needs to be tested with a broad range of potential biological agents.

*For explanatory notes a-g, see page 186.

F. TRANSPORTATION, STORAGE AND DISTRIBUTION

Introduction

The transportation, storage and distribution of water is briefly discussed in this section. The individual soldier's supply containers consist of canteens and five-gallon containers. The 400-gallon water tanker is the general means of supplying company-size units. Larger tankers and trailers are also available for water transport. The use of aerial supply, supply by large tanker ships, and distribution by pipeline are also methods employed or being considered by the military for large scale transportation, storage and distribution of water.

Special problems concerning transportation, storage and distribution of water in hot and cold climates are considered where appropriate. Heating, cooling and freezing problems are specifically addressed.

TOPIC 1: Transport of Potable Water in 500 Gallon Tankers and 1000 Gallon Trucks

Situation: *Operational Environment - All*
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

1) Transport does not contaminate water.

2) Transport vehicle is amenable to loading at supply point and unloading at distribution points.

Equipment:

The following vehicles are preferred:[1]

1) M972 - 5,000 gallon water tanker,
2) M50 - 1,000 gallon water truck,

For emergency use the following vehicles are provisionally suitable:

1) M131 - 5,000 gallon POL tankers,
2) M50 - 1,000 gallon POL truck.

Procedures:[2]

1) Water transport vehicles must be clean when arriving at a water supply point.

2) Vehicles previously used to haul non-potable water should be cleaned and disinfected with a 100 ppm chlorine solution.

3) POL vehicles should be cleaned with detergent, rinsed, and disinfected prior to use for transporting potable water.

4) Residual chlorine levels should be periodically checked and maintained as necessary.

Effectiveness:

1) The M50 1000-gallon truck and M972 5000-gallon tanker are capable of five 34 mile (one-way distance) delivery trips per day (based on 20 MPH travel speed).[1]

2) Water stored and transported in 5000-gallon POL tankers will satisfv minimum requirements defined in TB MED 229.[3]

3) Taste and odor may be imparted to water transported or stored in converted POL vehicles. Treatment with activated carbon is capable of removing the species responsible.[4]

Field Experience:

1) No problems were reported with 1000 gallon water tankers used in Vietnam.

2) Water transported in cleaned 5000-gallon POL tankers meets minimal potable requirements of TB MED 229, but imparts a taste and odor to the water which makes it unpalatable.

POTENTIAL HEALTH EFFECTS

1) Possible toxic effects from residual oils or other organic chemicals.

2) Dehydration due to reluctance to consume unpalatable water (see Section III C, Topic 4).

DOCUMENTATION*

1) "Letter of Instruction on Water Distribution in a Desert Environment," Dept. of the Army, U.S. Army Logistics Center, Fort Lee, VA 23801.[e]

2) FM 21-10. "Field Hygiene and Sanitation." July 1970.[f]

3) Gould, P., "Water Supply and Distribution Equipment for the Rapid Deployment Force," March 1980, Inst. for Defense Analyses, Paper P-1487, Alexandria, VA.

4) Allen, D.H., "Evaluation of Activated Carbon for Fuel Oil Adsorption from a Portable Water Supply," Tyndall AFB, FL 32401, AD #A037478,[a] (1976).

DATA GAPS AND RESEARCH NEEDS

1) A test procedure is required to determine if any (non-biological) agent contamination is present in delivered water.

2) The palatability of water transported in POL vehicles should be evaluated.

3) Methods to test if water has been contaminated (biological, chemical, etc.) during transport are not presently available and should be developed.

4) The laboratory work[4] which indicates that activated carbon will remove oil contamination and restore palatability of water should be extended and operational systems should be developed.

*For explanatory notes a-g, see page 186.

TOPIC 2: Transportation by 500 Gallon Water Drum (for Aerial Water Resupply)

Situation: *Operational Environment - All, Especially Arid or Arctic Regions*
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

1) Container is suitable for aerial delivery.

2) Does not contaminate water.

Equipment:[1,2]

A 500-gallon POL drum with a water compatible lining is under development. Couplings and fittings that are compatible with water pumps and hoseline are also being developed.

Effectiveness:[1,2]

Not yet in effective operation.

Field Experience:

1) No documentation of experience.

POTENTIAL HEALTH EFFECTS

1) Possible toxic effects from contaminants leached from POL drums (see Section III C, Topic 2).

2) Dehydration effects due to reluctance to consume unpalatable water (see Section III C, Topic 1).

DOCUMENTATION*

1) Lacquement, H.W., "Fourth Meeting of the JWG on Water Distribution," letter, 17 Oct. 1978, Dept. of the Army, U.S. Army Logistics Center, Fort Lee, Virginia 23801.[e]

2) "Letter of Instruction on Water Distribution in a Desert Environment," Dept. of the Army, U.S. Army Logistics Center, Fort Lee, VA 23801.[e]

DATA GAPS AND RESEARCH NEEDS

1) The chemicals (if any) which are leached from the POL drums should be identified.

2) The potential toxicity of POL drum leachate present in water should be determined.

*For explanatory notes a-g, see page 186.

3) Reaction of chlorine with POL drum material should be studied to check for deterioration of water during storage.

4) The palatability of the stored water as a function of time should be investigated.

TOPIC 3: Water Delivery and Storage by Converted Oil Tankers

Situation: *Operational Environment - Arid or Arctic Regions*
Operational Characteristics - Large Field Units

REQUIREMENTS

Criteria for water delivery and storage:

1) Deliver and/or store large quantities of water

2) Does not contaminate water

3) Accessible to distribution on shore

Equipment:

The following oil tankers are being considered for conversion to water tankers:[1]

1) T-5 class ship, capacity 6.5 million gallons,

2) Sealift class ship, capacity 6.7 million gallons,

3) Columbia class ship, capacity 6.7 million gallons.

Effectiveness:

1) One tanker can store four times the quantity needed by a 27,000-man RDF build-up over a three-week period.

2) Taste and odor may be imparted to water. Treatment with activated carbon is capable of removing the fouling organics.[2]

Field Experience:

1) Water transported by oil tanker to Guantanamo Bay by the U.S. Navy has been pumped to storage reservoirs and has subsequently undergone additional treatment.

POTENTIAL HEALTH EFFECTS

1) Possible Toxic effects from contaminants leached from POL drums (see Section III C, Topic 2).

2) Dehydration effects due to reluctance to consume unpalatable water (see Section III B, Topic 1).

DOCUMENTATION*

1) Gould, P., "Water Supply and Distribution Equipment for the Rapid Deployment Force," March 1980, Institute for Defense Analyses, Paper P-1487, Alexandria, VA.

2) Allen, D.H., "Evaluation of Activated Carbon for Fuel Oil Adsorption from a Potable Water Supply," Tyndall AFB, FL 32401, AD #A037478, 12 pgs. (1976).

DATA GAPS AND RESEARCH NEEDS

1) The chemicals (if any) which are leached from the POL drums should be identified.

2) The potential toxicity of POL drum leachate present in water should be determined.

3) Reaction of chlorine with POL drum material should be studied to check for deterioration of water during storage.

4) The palatability of the stored water as a function of time should be investigated.

*For explanatory notes a-g, see page 186.

TOPIC 4: Individual Water Storage

Situation: *Operational Environment - All Climate/Topography Locations*
Operational Characteristics - Individual Soldier in the Field

REQUIREMENTS

Criteria:

Container must be sufficient to carry adequate quantities of water and maintain the potability of the water.

Equipment:

1) One-quart canteens, rigid plastic or metal

2) Two-quart collapsible canteen

3) Insulated canteen, double-walled metal container

4) Five-gallon can, plastic, steel, and aluminum models.

Effectiveness:

1) The canteen has been used without major problems. The availability of the two sizes has led to some confusion if a soldier has to disinfect his own water supply because disinfection dose directions are given on a per canteen basis. In cold climates the water will freeze and in hot climates the water will be warmed.

2) The insulated canteen for use in cold climates slows the freezing process but freezing does occur around the neck of the canteen and it is difficult to thaw.

3) The 5-gallon can has been used without major problems. The steel can is useful in cold climates because it can be heated, but repeated heating may cause the paint lining of the can to crack and the steel will then rust, making it necessary to dispose of the can. A removable insulating cover retards freezing in cold climates, and facilitates thawing of frozen water. The current plastic 5-gallon can is used in regions other than cold climates. It is black which enhances solar heating of the water in hot climates. The insulating cover, when used, is also effective in keeping water cool in hot climates.

Field Experience:[1]

1) Soldiers in Vietnam preferred to carry both types of canteen. The 1-quart rigid canteen could be filled more easily from surface waters than the 2-quart collapsible canteen. The 2-quart canteen facilitates carrying larger quantities of water and collapses after the water is consumed.

2) The 2-quart collapsible canteen is easily punctured.

3) The 5-gallon can was used extensively and without problem in Vietnam.

Field Interviews:

1) Insulated canteen design for cold climates needs to be improved.[2]

2) The insulation and design of canteens and 5-gallon cans should be reviewed with respect to keeping water cool in hot climates and preventing freezing in cold climates.[2]

POTENTIAL HEALTH EFFECTS

Dehydration, if containers cannot supply sufficient water to the soldier. (see Section III B, Topic 1).

DOCUMENTATION*

1) Benefield, R.O.; "Water Supply in the Republic of Vietnam Jan. 31 to June 30, 1967," AD825260,[a] 118 pgs., 1967.

2) Interview with personnel at U.S. Army Natick Research and Development Command, Food Engineering Laboratory and Aeromechanical Engineering Laboratory, Natick, MA," 10 March 1981. (Appendix A, 1.6)

DATA GAPS AND RESEARCH NEEDS

1) Improved canteens for cold climate regions and hot arid regions needs to be developed.[2]

2) An alternative to the black 5-gallon can for hot arid regions needs to be developed.

*For explanatory notes a-g, see page 186.

TOPIC 5: Water Distribution to Field Units

Situation: *Operational Environment - All Climates/Geographic Locations*
Operational Characteristics - Small/Medium Size Field Units

REQUIREMENTS

Criteria:

Delivery of 400 to 1200 gallons of potable water per day.

Equipment:

400-gallon water trailer, 1-1/2 ton, 2-wheeler (TM5-700),[1] (TM-2330-213-14)[2] (New stainless steel, M149 series water trailers are now being distributed to some units)

Effectiveness:

1) Generally sufficient to supply water to company-size units.

2) Does not protect water from freezing in cold climates or from heating in hot climate.

Field Experience:

1) The trailer is satisfactory for supply to unit locations accessible by ground transportation.

POTENTIAL HEALTH EFFECTS

1) None documented, but dehydration effects from reduced consumption of unpalatable warm water might be anticipated.

DOCUMENTATION*

1) TM 5-700. "Field Water Supply," Dept. of the Army, July 1967.[f]

2) TM 9-2330-213-14. "Trailer, Tank, Water: 1-1/2 Ton, 2-Wheel, 400-Gallon M107A1," Dept. of the Army, August 1972.[f]

DATA GAPS AND RESEARCH NEEDS

1) The adequacy of current procedures to ensure continued potability of water after transportation should be checked.

2) Means to heat the stored water in cold climates and cool it in hot climates need to be developed.

*For explanatory notes a-g, see page 186.

3) Treatment methods to improve palatability (taste and temperature) prior to consumption should be studied.

4) The thermal insulating capacity of the new M149 water trailers now being put into service should be investigated.

TOPIC 6: Tactical Water Distribution System (TWDS)

Situation: *Operational Environment - Arid Climates*
Operational Characteristics - Large Field Units, Rapid Deployment Forces

REQUIREMENTS

Criteria:[1,2]

1) Be capable of rapid deployment with commercially adopted or military standard components to deliver 600,000 gpd of potable water a distance of over 67 miles when operating in areas of the world where water sources are extremely limited.

2) All components must be compatible for use with potable water and be approved by the Surgeon General.

3) One trained company, with supporting transportation should be capable of establishing a minimum of 18-22 miles of operable system per day.

Equipment:[1,2]

The following components are being considered for the Tactical Water Distribution System.

1) Collapsible fabric water storage tanks, pillow type, of 20,000 gallon capacity. (Similar U.S. manufactured containers are in use in Saudi Arabia. Materials are compatible with potable water and approved by the Surgeon General.)

2) Diesel engine driven, military designed, low pressure (125 psi), high capacity, POL pumps converted to water use.

3) Conduit of 6-inch diameter hoseline or pipeline capable of assembly with with quick coupling devices.

4) If required, additional water treatment will be accomplished by chlorination at a location as close to the consumer as possible.

5) Water points will be established along the systems for further distribution.

Effectiveness:

1) Taste and odors may be imparted to water especially by the rubber components which are exposed to solar radiation and high ambient temperatures.

2) There is some danger of subsequent water contamination by covert or overt actions.

Field Experience:

Water supply by pipeline has been effectively used by the Israeli Army in the Sinai peninsula.

POTENTIAL HEALTH EFFECTS

1) The potability and palatability of water at the point of distribution may be unacceptable after extended contact with rubber components at elevated water temperatures.

2) Inadvertant contamination of the water may occur through repair or replacement of TWDS components or through covert actions which cause incapacity or casualty.

DOCUMENTATION*

1) Required Operational Capability for the Tactical Water Distribution System (ACN 23328) November 1978.[e]

2) Sitten, J.R.; Draft Independent Evaluation Plan (IEP) for Tactical Water Distribution System (TWDS) September 1979.[e]

DATA GAPS AND RESEARCH NEEDS

1) Tests should be made to prove that potable water transported and stored in TWDS maintains its potability and palatability.

2) Potable water delivered by TWDS is more vulnerable to chemical contamination than other systems. Simple, quick field methods to detect Maximum Permissible Concentration of leachates and/or toxic substance in TWDS delivered water, prior to distribution for consumption, should be investigated.

3) Reliable, simple, field methods to improve palatability of water for taste and temperature requirements prior to consumption may be required.

*For explanatory notes a-g, see page 186.

TOPIC 7: Containers for Aerial Delivery of Water Supply

Situation: *Operational Environment - Arid Climates*
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

The container must be suitable for aerial delivery and not contaminate the water.

Equipment:[1]

1) 3-gallon bladder,

2) 55-gallon drum,

3) 250-gallon collapsible drum,

4) 500-gallon drum.

Effectiveness:

1) Air transport can deliver 3000 gallons of water in one pass.

2) Containers will withstand impact of delivery.

3) It is necessary to have proper pumping equipment to utilize water from the 250- and 500-gallon water containers.

Field Experience:

The 3-gallon water bladders were field tested in Vietnam and no failures were observed.[2]

POTENTIAL HEALTH EFFECTS

None documented.

DOCUMENTATION *

1) Interview with personnel at U.S. Army Natick Research & Development Command, Natick, MA, March 1981. (Appendix A, 1.6)[b]

2) Benefield, R.O.; "Water Supply in the Republic of Vietnam Jan. 31 to June 30, 1967," AD825260,[a] 118 pgs., 1967.

3) Gould, P. and Buck, P., "Water Supply and Distribution Equipment for the Rapid Deployment Force," March 1980, Institute for Defense Analyses, Paper P-1487, Alexandria, VA.

*For explanatory notes a-g, see page 186.

DATA GAPS AND RESEARCH NEEDS

1) Data are needed to define the permissible storage period in the aerial delivery containers.

2) The mode and extent of contamination during extended periods of storage in the containers should be determined.

3) Equipment to pump water from the 250- and 500-gallon drums is not described in the military literature.

IV. FIELD SANITATION

A. Personal Hygiene

Introduction

Within the terms of reference used here, personal hygiene is equated with personal cleanliness. This is, without question, an important factor in maintaining the effectiveness of a military unit. Under combat conditions where washing, bathing and laundry facilities are essentially field expedients or austere equivalents of those available on military posts, it is essential that soldiers be educated as to the consequences of neglecting personal hygiene. Also, commanders should not only understand the reason for, but insist upon proper personal hygiene. The benefits of cleanliness are not only protection for the individual against disease and the spread of disease within a unit, but also make a real contribution to the morale of a unit.

The equipment and procedures currently prescribed for field use have been employed by the Army since World War II and are considered very effective for most geographic regions of the world. There does appear, however, to be limited experience in using these field methods in extremely cold and hot arid regions which suggests that further investigation or field testing is required.

TOPIC 1: Personal Hygiene - Hand Washing and Shaving

Situation: *Operational Environment - All Climates*
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

1) Potable water is required - approximately 0.5 gallons/person/day.

2) Warm or hot water is preferred for shaving.

3) Hand washing facilities must be available outside latrines and near to mess facilities.

Procedures:

1) Water can be obtained from 400-gallon water trailer, Lyster Bag or from the utensil final rinse cans at the mess tent.

2) Hot water can also be produced by heating a helmet with water over an open fire or placing a container on or near an operating internal combustion engine. However, the new helmet design is not amenable to heating water.

3) Hand washing devices and soap are required at latrines and adjacent to field kitchens in bivouac areas.

Effectiveness:

1) The above procedures have been effectively used since World War II. However, more innovative measures are required in extremely cold climates.[1,2]

Field Experience:

1) During FTX Reforger 79, 29% of the units inspected did not provide adequate hand washing facilities in latrine areas and 13% did not encourage troops to wash hands before eating[5].

Field Interviews:

1) Personal hygiene is very difficult under arctic conditions[1,3,4] and in practice is almost non-existent.[2] Severe hand chapping, due to lack of hot water are the reasons men do not wash their hands.[2,6]

POTENTIAL HEALTH EFFECTS

1) Bacterial dysentery and diarrhea from self-contamination.

2) Infections and sores from fecal contamination.

DOCUMENTATION*

1) Interview with personnel from Cold Regions Research & Engineering Laboratory (CRREL), Hanover, NH, 18 December 1980 (Appendix A, 1.1).[b]

2) Interview with personnel at the US Army Natick R&D Labs, Natick, MA, 8 December 1980 (Appendix A, 1.6a).[b]

3) FM 31-70. Cold Weather Operations, Basic Instructions, April 1968.[f]

4) FM 31-71. Northern Operations, June 1971.[f]

5) "Field Sanitation and Hygiene During FTX Reforger 79," Major J.A. Thomasino, Medical Bulletin of the US Army, Europe, Volume 37, No. 3, March 1980.[e]

6) Telephone Interview of Preventive Medicine Personnel Assigned to USAREUR, 15 April 1981 (Appendix A, 3.1).[b]

7) "Users' Meeting to Discuss the Field Sanitation and Water Problem Definition Study," Aberdeen Proving Ground, Edgewood, MD, 5/18/81 (Appendix A, 1.9).[b]

DATA GAPS AND RESEARCH NEEDS

1) Alternatives to cold water for individual toilet purposes should be identified. Impregnated wet wipes might be an alternative, particularly for arctic regions and in areas where water shortages exist.

2) With reference to use of utensil rinse water for washing and showering (Procedure 1 above), this procedure may provide means of transmission of disease if the rinse water is not hot enough.

3) Skin-care lotions have not normally been made an issue item for self-treatment of windburn, sunburn and chapped hands. The need for and a formulation for such a lotion(s) with antiseptic/disinfecting capability should be evaluated.[1]

4) The feasibility of using a small hot water heater for hand washing should be determined. One is currently manufactured in Norway.[7]

5) Hygiene problems (or lack of) specific to female soldiers should be documented[7] and appropriate solutions investigated.

*For explanatory notes a-g, see page 186.

TOPIC 2: Personal Hygiene - Barbering

Situation: *Operational Environment - All Climates*
Operational Characteristics - Individual Soldier

REQUIREMENTS

Criteria:[1,2]

1) Barbering tools should be kept clean.

2) No treatment of pimples or skin irritations should be permitted.

3) No service provided to persons with lice.

Procedures:[1,2]

1) Clean clippers and comb before using on each individual and disinfect at the end of each day.

2) Disinfection solutions are prepared using iodine or calcium hypochlorite.

3) Use separate towels, disposable tissues, etc., for each patron, or have individual furnish own.

Effectiveness:

1) No problems arise when a barber conscientiously observes prescribed procedures.

Field Experience:

1) The above procedures have been effectively used by military units in the field since World War II.

2) Local nationals often replace military barbers in stabilized situations.

POTENTIAL HEALTH EFFECTS

1) Skin rashes and infections.

2) Spread of head and body lice.

3) Spread of bacterial infections via contaminated instruments.

DOCUMENTATION*

1) TM 8-250, Environmental Health Technician, July 1974.[f]

2) AR 40-5, Health & Environment, September 1974.[f]

*For explanatory notes a-g, see page 186.

DATA GAPS AND RESEARCH NEEDS

1) None identified at this time.

TOPIC 3: Personal Hygiene - Clothes Laundering

Situation: *Operational Environment - All Climates*
Operational Characteristics - Field Laundry Units

REQUIREMENTS

Criteria:

1) Water for laundries and other cleaning purposes need not meet all the drinking water standards, but its use must not impair the health of personnel.[1,2]

2) Water consumption planning factors include 2.0-gallon/person/week for field laundry operations.[3]

3) Operations are based on 5 1/2 to 6 pounds of laundry per person per week.[3,4]

Procedures:

1) Laundry Unit, Trailer Mounted, M532 - Unit is self-contained, consisting of washer, extractor, dryer, water heater and engine generator.

2) Each laundry unit consumes 250 gallons of water per hour and is capable of operating 20 hours per day.

3) Washing is accomplished using detergent soap, and a laundry sour is used to neutralize any alkali in the clothing.

4) A laundry unit can also be used to reimpregnate protective clothing using a product identified as XXCC3.

5) Wastewater is discharged where it does not contaminate the water supply.

Effectiveness:

1) Field laundry equipment is effective in removing soil grease and NBC contaminants from clothing provided there is an adequate supply of water and prescribed soaps and washing solutions are used.

Field Experience:

1) Field laundry equipment is effective in removing soil grease and NBC contaminants from clothing provided there is an adequate supply of water and prescribed soaps and washing solutions are used.

2) Procedures for recycling laundry wastewater have been developed but not field tested. (Techniques are applicable to water-short regions).[2,6]

3) Infrequent bathing, laundering, and the lack of cleaning materials resulted in and contributed to a growing incidence of fungal infection among the Cuban population at Fort McCoy.[5]

Field Interviews:

1) A field test of the capability of the M532 Laundry Unit to remove chemical agent contaminants from clothing has been proposed.[7]

2) The general use of field laundries in cold climates is apparently not practiced.[7]

POTENTIAL HEALTH EFFECTS

1) Clothing soiled with feces, soil, sweat, cause most of the common skin diseases, especially in tropical/arid regions, and in cold regions where laundries are rarely used.[7]

2) Wastewater from laundries is a source of pollutants that can contaminate a water source, especially wastewater generated by laundering NBC contaminated clothing.

3) NBC contaminated clothing can transmit incapacitating agents to the body, producing illness or death.

DOCUMENTATION*

1) AR 115-20. Field Water Supply, August 1969 (under revision).[f]

2) Letter, USAMBRDL, Fort Detrick, Maryland; Subject: Interim Water Quality Criteria for Shower and Laundry Reuse/Recycle, dated 22 October 1980.[e]

3) Message 21 November 1980, USALOG Center, Fort Lee, Virginia (ATCL-CW), Subject: Multi-Service Water Consumption Planning Factors.[e]

4) TM 10-280, Field Laundry, Bath and Clothing Exchange Operations, July 1973.[f]

5) Rowles, E.M., 2LT, MSC, "Cuban Refugee Re-Settlement Task Force, Fort McCoy, WI, After-Action Report," 48th MEdical Detachment (LB), Fort Riley, KS, 4 July 1980.[e]

6) "Summary of Interview with Personnel at US Army Natick R&D Command, Food Engineering Laboratory, Natick, MA," 10 March 1980 (Appendix A, 1.6).[b]

*For explanatory notes a-g, see page 186.

7) Interview with personnel at US Army Research Institute for Environmental Medicine (USARIEM), Natick, MA, 12 December 1980, (Appendix A, 1.7).

8) Interview with personnel at U.S. Army Construction Engineering Research Laboratory (CERL), Champaign, IL, 15 Nov 1980, (Appendix A, 1.2).[b]

9) Interview with Combat Development Directorate, US Army Engineer School, USAES, Fort Belvoir, VA, 19 September 1980, (Appendix A, 2.2a).[b]

DATA GAPS AND RESEARCH NEEDS

1) Appropriate water quality criteria are needed for water used in laundry operations. The recently identified "interim" criteria[2] should be evaluated by conducting appropriate toxicology and equipment field tests. Adopted standards need to be incorporated into applicable regulations and manuals[8,9].

2) The Army should attempt a full-scale exercise in cold weather which actually deploys medical/surgical teams, laundry and bath units, and obtains raw water from other than local/municipal sources.[7] This would determine if field laundries are fully operable and effective in cold climates.[6]

3) The proposed wastewater treatment process for laundry washwaters should be tested in the field to verify both the operational and cost effectiveness of reusing this water for laundry or other purposes. Also, the equipment and procedures needed to permit the recycling and reuse of laundry wastewater should be identified.

4) There is a need for more specific guidance on the disposal of the laundry waste water, particularly after NBC decontamination operations. It is important to prevent contamination of water sources by the wastewater.

5) In hot, arid, water-short areas the use of throw away clothing should be considered as an alternative to laundering.[6]

TOPIC 4: Personal Hygiene - Personnel Showers

Situation: *Operational Environment - All Climates*
Operational Characteristics - Individual Soldier

REQUIREMENTS

Criteria:

1) Water for showers need not meet all drinking water standards, but its use must not impair the health of personnel.[1]

2) Potable water is specified for showering, however, interim water quality criteria for reuse and recycle of shower water are being considered.[2]

3) Water consumption planning factors include 1.3 gallon per person per day for an arid environment. This is based on 2 showers per week at 3 minutes each and using 4.5 gallons per shower.[3]

4) In non-arid areas, bath units consume up to 14 gallons of hot water per shower per person.[4]

Procedures:

1) Portable Bath Unit, M1958 contains 2 shower stands with four shower heads each, water heater, electric-motor-driven pump and small electric generator.[4]

2) Shower facility is equipped with foot baths containing calcium hypochlorite.

3) Bar soap and towel are provided.

4) A clothing exchange is normally integral to a shower point. Foot powder and insecticide powder is provided in the dressing station.

5) Wastewater is discharged where it will not contaminate water supplies.

Effectiveness:

1) No procedures have been published regarding the employment of shower units in the arctic.

2) The procedures that have been identified in current field manuals appear to permit the use of water withdrawn from a stream/river without any pretreatment.

3) Showering is the optimum procedure for the removal of NBC contaminants from body surfaces.

Field Experience:

1) No recent field experiences have been reported on the use of sub-potable water for showers.

2) Procedures have not been developed or field tested on the reuse of shower water.

3) During Operation Bold Eagle 80, a large number of patients with dermatological disease were seen during the first few days. These were mainly secondary bacterial infections of minor trauma reflecting poor personal hygiene. After shower points were set up and personal hygiene improved, dermatological problems decreased in numbers. However, bacterial skin infections (pyoderma) were noted in greater numbers toward the end of tactical play, again reflecting the poor personal hygiene that occurred during the last days of mythical war.[5]

Field Interviews:

1) No information is available on the employment of shower units in the arctic.[6]

POTENTIAL HEALTH EFFECTS

1) Schistosomiasis can be contracted from skin contact with unfiltered water in some areas of the world.

2) Ingestion of untreated water during showering could result in a variety of disease or illnesses that are debilitating (see Section III C, Topic 1).

3) Showers can contribute to the spread of foot diseases, e.g., athletes foot or foot fungus and ringworm.

4) typhus may be contracted from body lice.

5) Wastewater from showers, particularly NBC contaminated wastewater, is a source of pollutants that can contaminate a small water source.

DOCUMENTATION*

1) AR 115-20. Field Water Supply, August 1969 (under revision).[f]

2) Message 21 November 1980, USALOG Center, Fort Lee, Virginia (ATCL-CW), Subject: Multi-Service Water Consumption Planning Factors.[e]

3) LTR, USAMBRDL, Fort Detrick, Maryland; Subject: Interim Water Quality Criteria for Shower and Laundry Reuse/Recycle, dated 22 October 1980.[e]

*For explanatory notes a-g, see page 186.

4) TM 10-280. Field Laundry, Bath, and Clothing Exchange Operations, July 1973.[f]

5) Davilia, R., MD, Capt MC, Preventive Medicine Medical Officer After-Action Report, Bold Eagle 80, U.S. Army Medical Department Activity, Fort Bragg, N.C., 1 Nov. 1979.[e]

6) Interview with personnel at U.S. Army Research Institute for Environmental Medicine (ARIEM), Natick, MA, 12 Dec 1980 (Appendix A, 1.7).[b]

7) Users' Meeting to Discuss the Field Sanitation and Water Problem Definition Study, Aberdeen Proving Ground, Edgewood, MD, 5/18/81. (Appendix A, 1.9)[b]

DATA GAPS AND RESEARCH NEEDS

1) Information is needed on the acceptability of using non-potable water for showers. Non-potable water standards need to be defined.

2) A simple field water treatment/recycling system which is compatible with the portable field bath unit is required, particularly for regions where water supplies are limited.[3,5]

3) Instructions on the proper disposal of NBC contaminated shower wastewater are not contained in TM 10-280. This deficiency should be corrected.[4]

4) The feasibility of reducing shower water use in the desert by substituting frequent sponge baths should be determined.

5) The use of water-on-demand showers as a water conservation measure rather than the continuous flow type now used should be considered.[7]

6) The frequency of showers necessary to maintain good health should be investigated.[7]

B. Human Waste Disposal

Introduction

Human wastes, both feces and urine, can be a very significant source of disease when not properly disposed of by a military unit. Such wastes can quickly become an ideal breeding area for insects, rats and other vermin. They are also the common source of such diseases as dysentery, typhoid, paratyphoid, cholera and plague.

The most common and traditional disposal method used by individual military personnel and units has been burial. However, in regions where the ground is frozen or extremely rocky or where the water table is close to the surface, incineration may be the only recourse. Over the years, a variety of simple and effective field expedient devices using burial and incineration techniques have been developed and used by the Army. As a result, there appear to be no technological or procedural deficiences except when tactical conditions preclude incineration because of the smoke produced. This particular constraint produces a potentially significant problem when burial is not a practical alternative to incineration.

The issue of greatest importance relative to human waste disposal is the apparent lack of training and experience in the use of field expedient devices. Today, many training installations prohibit the digging of slit trenches and pit latrines because of the perceived requirement to refrain from polluting the natural environment. The common substitute device is the portable chemical latrine, which is not suitable under combat conditions.

TOPIC 1: Human Waste Disposal - Individual Soldier

Situation: *Operational Environment - All Climates*
Operational Characteristics - Individual Soldier in the Field

REQUIREMENTS

Criteria:

Safe disposal which will not contaminate the individual, a water supply, or serve as a breeding area for vermin.

Procedure:[1]

1) Dig a cat hole approximately one foot deep.

2) Cover and pack down after use.

Effectiveness:

In an area which is not frozen, rocky, or has high groundwater, the method should be effective to prevent groundwater contamination. If the cat hole is packed and mounded, there will probably be no problem with insect breeding. The procedure does not address the personal hygiene aspects of waste disposal and hand to mouth infection may be possible.

It is difficult for a soldier in NBC protective clothing to defecate or urinate.[2]

Field Experience:[3]

1) In the Boer War the British troops commonly followed rivers when marching in the field. The indiscriminate disposal of waste while marching and/or bivouacing resulted in contaminating rivers and providing areas for fly infestations. The former practice was the cause of 8000 men (10% of the troops) dying of typhoid.

POTENTIAL HEALTH EFFECTS

Water may be contaminated by human waste (directly or indirectly) and result in subsequent ingestion of pathogens by soldiers. Insects may cause the spread of disease vectors. Improper individual hygiene may cause direct hand-to-mouth exposure to pathogens.

DOCUMENTATION*

1) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

*For explanatory notes a-g, see page 186.

2) Users' Meeting to Discuss the Field Sanitation and Water Problem Definition Study, Aberdeen Proving Ground, Edgewood, MD, 5/18/81. (Appendix A, 1.9)

3) "Field Water Supply and Waste Disposal," Academy of Health Sciences, Preventive Medicine Division, course LP 73-430-124.[e]

4) Telephone Interview of Preventive Medicine Personnel Assigned to USAREUR, 15 April 1981 (Appendix A, 3.1).[b]

DATA GAPS AND RESEARCH NEEDS

1) Current training does not stress the importance of proper human waste disposal in the field.[4]

2) Troops seldom practice waste disposal procedures in the field. In the stress of a real combat situation, a soldier will probably not carry out a secondary (unsupervised) function properly and safely that he has not previously practiced.[4]

3) There is the threat of secondary infection of the soldier or a water supply (i.e., lyster bag, canteen) due to improper hygiene after disposal. This appears to warrant some forms of disposable hygienic wipes be p:cvided each soldier for field use.[4]

4) Preventive Medicine personnel should evaluate waste disposal practices during field exercises and make appropriate recommendations.[2]

5) NBC protective clothing should be redesigned to provide a better method of defication and urination.[2]

TOPIC 2: Human Waste Disposal - Unit in Bivouac

Situation: *Operational Environment - All Climates*
Operational Characteristics - Small Unit in the Field (Bivouac Conditions)

REQUIREMENTS

Criteria:

1) Protects against primary disease

2) Protects water sources and food from contamination

3) Protects from vermin infestations

Primary Disposal method: Straddle trench latrine

Procedure:[1]

1) Latrine location should be at least 100 yards from unit mess and 100 feet from water source.

2) Construct a 1-foot wide, 2-1/2 feet deep and 4-feet long straddle trench latrine. One trench can service two soldiers at a time. Sufficient trenches should be dug to service 8% of the soldiers at one time.

   Pile the excavated dirt at the ends of the trench.

3) Dig a drainage ditch around the trench.

4) Construct a hand washing device near the straddle trench.

5) Cover excreta with earth immediately after use.

6) Close the trench when waste is within one foot of the top or site is being abandoned. The closing procedure is to:

   i. spray contents and walls with disinfectant,
   ii fill and pack,
   iii mound over,
   iv. spray again with insecticide.

Effectiveness:

1) In a dry, well drained area, the straddle trench will satisfy the criteria for waste disposal. In areas which are rocky, wet, or have high water tables, the straddle trench will not be sufficient to meet the criteria for field waste disposal.

2) The disinfectant currently used is not effective against viruses.[2]

Alternative Disposal Methods:

1) Deep pit latrine.[1]

2) Burn out latrine (55 gal. drum or pail).[1]

3) Portable latrine unit transported to the site.

Field Experience:

1) Unrealistic field sanitation training was observed at Fort Drum. There, and at other field training sites, bivouac areas are positioned near permanent outhouses or portable latrines are used.

2) About 12% of the 52 units inspected during FTX Reforger 79 did not have adequate numbers of latrines and 12% did not keep latrines in sanitary condition.

3) The following observation was made by the Brigade Preventive Medicine Officer regarding Operation Brave Shield 80: "The use of portable toilets should be discouraged. The potential for disease spread due to human waste is immense and necessary precautionary measures must be practiced to obtain proficiency".

4) Poor sanitation practices at troop assembly areas during the 1958 Lebanon Intervention resulted in 50% of U.S. soldiers contracting diarrhea and dysentery.

POTENTIAL HEALTH EFFECTS

Water may be contaminated by human waste (directly or indirectly) and result in subsequent ingestion of pathogens by soldiers. Insects may cause the spread of disease vectors. Improper individual hygiene may cause direct hand-to-mouth exposure to pathogens.

Field Interviews:

1) Specifications in FM 21-10 for the number of latrines should be lowered to accommodate 4% of the men and 6% of the women at one time and for urinals to accommodate 5% of the males at one time.[7]

DOCUMENTATION*

1) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

2) Bowman, L.H. III, et al.; "Virucidal Capacity of a Chlorophenolic Disinfectant," Devel. in Industrial Microbiology, Vol. 20, pgs 673-681 (1979).

3) After-Action Report Field Training Exercise 42nd Infantry Division New York National Guard, 22 July - 5 August, 1980, U.S. Army Environmental Hygiene Agency, Edgewood Arsenal, MD.

4) Thomasino, J.A., Major MC, "Field Sanitation and Hygiene during FTX Reforger 79, Medical Bulletin of the U.S. Army Europe, Vol. 37, No. 3, March 1980 (3 pages).[e]

5) "Operation Brave Shield 80, After-Action Report," Brigade Preventive Medicine Officer, undated.[e]

6) "Field Water Supply and Waste Disposal," Academy of Health Sciences, Preventive Medicine Division, course LP 73-430-124.[e]

7) Interview with personnel at the First Medical Group, Fort Hood, Texas, 3 November 1980 (Appendix A, 5.2).[b]

DATA GAPS AND RESEARCH NEEDS

1) Current training does not adequately stress the importance of proper field waste disposal. The ability of troops to carry out these procedures should be tested in field exercises.[5]

2) The threat of secondary infection due to improper hygiene after using the latrine may warrant development of hygienic hand wipes or other alternative field hand washing devices.[4,5]

3) Research on a disinfectant which kills viruses in waste is needed.[2]

4) Expedient methods of human waste disposal which can be employed by a small tactical unit (company) in the arctic or northern regions should be identified and described in the appropriate field manuals.[1]

5) Policy guidance and operational instructions should be developed which stress to training installation commanders the importance of increased use of field expedient methods of human waste disposal and minimize reliance on portable toilets during field exercises[3,5]

6) The guidance provided in FM 21-10 on the number of sanitary devices required for a given size of force should be re-evaluated.[7]

*For explanatory notes a-g, see page 186.

TOPIC 3. Human Waste Disposal - Camp or Base

Situation: *Operational Environment - All Climates*
Operational Characteristics - Large Units in Base Camps

REQUIREMENTS

Criteria:

1) Prompt and complete disposal in a manner that prevents infection of the individual or contamination of a water supply source, and does not attract or serve as a breeding area for flies and vermin.

2) Facilities should be simple, effective and quickly installed.

Procedures:[1,2,3,4]

1) Construct urinals with soakage pits.

2) Provide pit latrines where soil conditions permit.

3) Use burn-out, mound, or pail latrines in areas where ground is hard, rocky, frozen, or where there is a high water-table.

4) Provide hand washing facilities adjacent to latrines.

5) Clean latrines daily; spray with residual insecticide twice weekly; close when one foot from the surface (except pail and burn-out latrines); and mark location and indicate date of closure.

6) Preventive medicine personnel perform periodic inspections of latrine facilities for cleanliness and operational condition, and spray with insecticide on a regular schedule.

Effectiveness:

1) Procedures and expedient devices are effective for short-term camps and bases;. these may be replaced for long-term use by a waterborne sewage system.

2) Burn-out latrines are probably the most convenient of the devices for the arctic, but the tactical situation may preclude their use due to the smoke produced.

3) U.S. Army disposal methods may have to be modified for POW & refugee camps to suit cultural preferences.

Field Experience:

1) The procedures and devices contained in FM 21-10[1] were effectively employed during World War II, Korea and Vietnam.

Field Interviews:

1) In frozen regions of the arctic, human waste has been collected in plastic bags, allowed to freeze, and disposed of at a later date by burial, incineration or ocean dumping.[5]

2) The World Bank in its assistance programs in certain foreign countries found that local inhabitants avoided use of newly constructed sanitary facilities because they were not compatible with local sanitary cultural preferences.[6,7]

3) Topographical information should be available for planning waste disposal in the field.[8]

POTENTIAL HEALTH EFFECTS

1) Latrines can contaminate water supplies directly or indirectly.

2) Wastes promote insect infestation and rodent harbors.

3) Latrine use contributes to improper individual hygiene (See Personal Hygiene Section IV-A).

DOCUMENTATION*

1) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

2) "Field Water Supply and Waste Disposal," Academy of Health Sciences, Preventive Medicine Division, course LP 73-430-124.[e]

3) TC 8-3. Field Sanitation Team Training.[e]

4) Field Preventive Medicine Resource Guide for AMEDD Personnel, Academy of Health Sciences, Preventive Medicine Division.[e]

5) Interview with personnel from Cold Regions Research & Engineering Laboratory (CRREL), Hanover, NH, December 18, 1980 (Appendix A, 1.1).[b]

6) Interview with World Bank Office for United Nations Development Program (UNOP) Global Water & Sanitation Project," Washington, D.C., 11 March 1981, (Appendix A, 5.6b).[b]

7) After-Action Report, Cuban Refugee Settlement Task Force, Fort McCoy, WI, 9 July 1980.[e]

8) Interview Conducted at Terrain Analysis Center (TAC) of the Engineer Topographic Laboratory (ETL), Fort Belvoir, VA, 12 March 1981, (Appendix A, 4.7).[b]

*For explanatory notes a-g, see page 186.

9) Elmendory, M. and Buckles, P., Sociocultural Aspects of Water Supply and Excreta Disposal, World Bank, December 1980.[e]

DATA GAPS AND RESEARCH NEEDS

1) Procedures are needed that can be used in arctic regions to effectively dispose of human wastes.[1,5] Procedures used by civilian communities in the northern areas can be used for semi-permanent camps; however, short-term camp facilities require more detailed examination.

2) Used engine oils and contaminated fuels may be used effectively and safely for burn-out latrines and thereby reduce the need for other fuels. If such is feasible, instructions should be included in FM 21-10.

3) The collection of human wastes in plastic bags and their storage for disposal at a later date when the ground thaws may be a practical procedure for a military unit operating in cold regions.[5] If such a procedure is practical, detailed guidance should be published.

4) Guidance relative to field sanitation procedures in the northern climates is extremely limited. It appears that units are left to adapt those techniques in FM 21-10 to the best of their ability. This subject requires special attention in the manual.[1]

5) Preplanning Preventive Medicine procedures in potential overseas operational areas currently appear to be superficial because of the lack of information on topography, climate, soils and groundwater conditions. The data available in Terrain Analysis Studies prepared by the Engineer Topographic Laboratories should be evaluated by medical planners to assess their value in predicting field sanitation problems and the means to overcome them.[8]

6) Lack of information regarding local sanitation practices in many countries could complicate the operation of POW and refugee camps constructed and operated by the Army. The need for a data bank of local sanitary customs that would aid medical planners should be evaluated.[7,9]

7) There is a need to investigate and provide guidance for specific problems affecting female personnel using field expedient methods.

C. Food Service Operations

Introduction

Wastes produced from food service operations include trash, garbage and wastewater from mess cleaning activities. Like human waste, they also constitute a breeding ground for flies and vermin and can be a source of incapacitating diseases unless properly disposed of.

Field expedient means of disposal have been developed and have been employed effectively by the Army in various combat theaters since World War II. In general, the combination of burial and incineration methods have proven most successful. However, these options can be constrained by the tactical situation which may preclude open burning and by such terrain conditions as frozen and rocky ground, or shifting sand which may preclude burial.

Of the various sanitation problems associated with food service operations the most troublesome appears to be those surrounding the cleaning of cooking and serving utensils. Primarily, the difficulties have been and continue to be related to the production of adequate quantities of boiling water for washing and the large amount of water required by a unit mess.

As with other facets of field sanitation, there also appears to be a lack of experience in the proper operation of a field mess. This is a reflection of the limited opportunity for field training given to food service personnel and inadequate instruction of the individual soldier on his responsibility to avoid the ingestion of contaminated food.

TOPIC 1: Garbage and Rubbish Disposal - Camp and Base (Troop, POW & Refugee)

Situation: *Operational Environment - All Climates*
Operational Characteristics - Large Units in Base Camps

REQUIREMENTS

Criteria:[1]

1) Dispose of these waste materials promptly after generation.

2) Once disposed, wastes shall not contaminate water sources or constitute a nuisance.

3) Burial pits or trenches should be at least 100 feet from a mess facility or water source used for producing potable water.

4) Disposal methods should effectively prevent attraction of flies, rodents and other animals.

Procedures:[2,3,4]

1) Solid wastes are placed in cans/boxes or other containers and periodically collected for transport to a disposal site.

2) Combustible materials are normally burned.

3) Putrescible materials and non-burnable wastes are customarily buried.

4) Disposal by ocean dumping is listed as an accepted procedure. (See also Section IV C, Topic 6, for disposal of mess hall garbage.)

Effectiveness:

1) Disposal of garbage in pits, trenches or other forms of landfill are the preferred method because they are most economical and effective.

2) Burial would not be possible in locations with rocky or frozen ground, or in areas with a high water table.

3) Burial in the desert may only be temporary due to shifting sands.

Field Experience:

1) Burning and burial of solid wastes was effectively employed in World War II, Korea and Vietnam.

2) Scavenging of solid wastes by local inhabitants in a theater of operations has been common and difficult to control.

Field Interviews:

1) Field sanitation can become a problem for the Army in the field.[5]

2) Information on soils and topography would assist the planner in identifying effective waste disposal for a specific area.[7]

POTENTIAL HEALTH EFFECTS

1) Improper handling or disposal of garbage and rubbish attract flies and rodents that can spread disease.

2) Contamination of ground and surface water may result from poorly sited and operated disposal sites.

DOCUMENTATION*

1) AR 40-5. Health and Environment, September 1974.[f]

2) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

3) FM 10-23. Army Food Service Operations, September 1978.[f]

4) Preventive Medicine Technical Guide, 20th Preventive Medicine Unit (SVC) (FLD) APO 96227, 1968.[f]

5) "Theater of Operations Construction in the Desert - a Handbook of Lessons Learned in the Middle East," CERL, January 1981.[e]

6) Interview with personnel at the Office of the Surgeon General of the Army (OSTG) HQ DA, 17 Sept. 1980, (Appendix A, 2.4).[b]

7) Interview with personnel at the Terrain Analysis Center (TAC), of the Engineer Topographic Laboratory (ETL), Fort Belvoir, VA, 12 March 1981, (Appendix A, 4.7).[b]

8) Hassett, R.J., 1 LT MSC, "Operation Brave Shield 80, After-Action Report," 225 Medical Detachment (LC), undated.[e]

DATA GAPS AND RESEARCH NEEDS

1) Guidance is needed on acceptable methods for disposing of garbage and other non-combustible wastes in arctic areas, locations with high water tables, and in desert areas with moving sands (dune areas).[2,5]

2) Under current conditions, where efforts are being made to protect the ocean environment, the Army should review and update its policy on ocean disposal for its solid wastes.[1,2]

*For explanatory notes a-g, see page 186.

3) Information about soil and climatic conditions in various regions of the world would be exceedingly helpful to military planners so that advance information can be provided and guidance developed on the proper and effective sanitation procedures to be employed.[6,7,8] (See also Section IV C, Topic 6)

TOPIC 2: Garbage and Rubbish Disposal - Tactical Units

Situation: *Operational Environment - All Climates*
Operational Characteristics - Small Field Units

REQUIREMENTS

Criteria:

1) Dispose of waste materials promptly after generation.

2) Once disposed, wastes should not be accessible to insects or rodents, shall not contaminate water sources, or constitute a nuisance.

3) Disposal sites should be located at least 100 feet from a water source, and garbage disposal sites at least 100 feet from a mess area.

Procedures:[1]

1) In bivouacs for less than 1-week duration garbage is disposed of by burial in pits or trenches.

2) A pit 4 feet square and 4 feet deep is suitable for 1 day for a unit of 100 men for disposal of garbage.

3) The continuous trench is more adaptable for stays of 2 days or more. A trench is initially dug about 2 feet wide, 3 to 4 feet deep and long enough to accommodate garbage for each day.

4) When a pit or trench is filled to 1 foot from the surface, spray waste with insecticide, fill with dirt, mound with an additional foot of compacted earth and mark.

5) In temporary camps or bivouacs, garbage and rubbish are normally buried together; for stays over one week, rubbish is usually burned in a barrel incinerator.

Effectiveness:

1) the above disposal procedures were effectively employed by the Army during World War II, Korea and Vietnam.

2) The frozen conditions in the arctic present problems in the disposal of both garbage and rubbish.

3) Disposal by burning could be precluded by the tactical situation where it would not be appropriate to produce smoke.

Field Experience:

1) Units on field training exercises commonly transport solid waste and garbage to the installation for disposal.

2) Lack of experience in the construction and operation of sanitary landfill procedures can lead to unsanitary conditions such as encountered during Operation Brave Shield 80.[2]

POTENTIAL HEALTH EFFECTS

1) Improperly disposed garbage and rubbish can attract insects, rodents and larger animals such as wolves and bears which are often carriers of disease.

2) Surface runoff from waste disposal sites can contaminate water supply sources on the camp site and become a source of disease.

DOCUMENTATION*

1) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

2) Hasset, R., 1LT, MSC, "Operation Brave Shield 80, After-Action Report," 225 Medical Detachment (LC), undated.[e]

3) Interview with personnel from Cold Regions Research & Engineering Laboratory, (CRREL), Hanover, NH, 18 December 1980 (Appendix A, 1.1).[b]

Field Interview:

1) The disposal of food residues in sealed plastic bags is an alternative method used in the arctic.[3]

DATA GAPS AND RESEARCH NEEDS

1) Alternative procedures other than burning[1,2,3] should be identified for the disposal of solid waste and garbage in the arctic, rocky areas, and areas with high water tables.

*For explanatory notes a-g, see page 186.

3. TOPIC: Garbage and Rubbish Disposal - Individual Soldier

Situation: *Operational Environment - All Climates*
Operational Characteristics - Individual Soldier

REQUIREMENTS

Criteria:

1) Disposal should be prompt to avoid attracting insects and animals.

2) Care should be exercised in burying wastes in areas with high water table or marshy ground.

Procedures:[1]

1) Excavate hole with entrenching tool and cover solid waste with at least 12 inches of soil.

2) Use burnable waste materials as a source of fuel for burning food residues.

Effectiveness:

1) The effectiveness of these procedures is dependent on the discipline of of the soldiers.

2) To be effective, application of procedures requires command attention.

3) All components of the waste are biodegradable except metals and plastics. (Biodegradation may not occur in cold regions).

Field Experience:

1) Proper disposal of wastes from "C" and "K" rations is difficult to achieve, particularly under combat conditions.

POTENTIAL HEALTH EFFECTS

1) Improper disposal of wastes promotes infestation of flies and other insects, and attracts rodents that are disease carriers.

2) Metal wastes can cause minor injuries to those inadvertently contacting sharp edges. Cuts and scrapes may require prompt medical attention, particularly in hot humid climates.

DOCUMENTATION*

1) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

*For explanatory notes a-g, see page 186.

DATA GAPS AND RESEARCH NEEDS

1) Commanders need to be informed of the possible consequences of poor field sanitation procedures.

2) The procedures on garbage and rubbish disposal in FM 21-10 need to be re-evaluated.

TOPIC 4: Food Service Operation - Cooking, Serving, and Eating Utensil Cleaning

Situation: *Operational Environment - All Climates*
Operational Characteristics - Company and Larger Size Units

REQUIREMENTS

Criteria:

1) Complete removal of residual food.

2) Disinfection of utensils.

3) Sanitary disposal of food residues and wastewater.

Procedures:[1,2,3]

1) Remove excess food.

2) Wash, rinse and disinfect.

3) Air dry utensils.

4) Construct soakage pit for wastewater.

5) Bury solid food wastes.

Effectiveness:

1) Immersion heaters are susceptible to malfunction, and may not provide water hot enough to kill pathogenic organisms.

2) Heaters require constant maintenance and faulty adjustments have resulted in burn casualties.

3) Large quantities of potable water are required, which in arid regions may not be conveniently available. Cleanliness could be jeopardized in such locations.

4) Trichlormelamine (Disinfectant Food Service MIL-D-11309E) is used in cold water. This disinfectant effectively destroys bacteria, virus, and parasites. In order to ensure adequate availability of an effective disinfectant, U.S. Army Natick Research & Development Laboratories are investigating alternative food service formulations.

Field Experience:

1) Cleanliness of mess facilities is a constant problem.

2) Washing facilities have to be improvised using field expedients (e.g., fabrication of sinks from 55-gallon drums).

3) Disinfection procedures using chlorine disinfectant (FSN 6840-270-8172) or calcium hypochlorite solution are rarely used.

4) Difficulty was reported in washing pots and pans where only 32-gallon cans were available. A portable sink was suggested for field use because of the large size pots in use.[4,5]

5) A field sink has been developed for the U.S. Marine Corps by the Army Food Engineering Laboratory for use by battalion-size units.[6]

Field Interview:

1) It is difficult to clean bulky pots and pans using the current equipment.[4]

2) A field sink has been developed by the U.S. Army Natick Food Engineering Laboratory and adopted for use by Marines to service battalion-size units. The field sink or some modification has potential to be utilized by Army company-size units as an alternative to the immersion heaters and G.I. cans in current use.[6]

POTENTIAL HEALTH EFFECTS

1) Improper cleaning may result in outbreaks of food poisoning, dysentery, infectious hepatitis, and typhoid fever.

2) Dirty mess facilities attract flies and can cause odor problems.

3) Food wastes and wastewaters attract flies, insects and rodents which are germ carriers.

DOCUMENTATION*

1) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

2) TM 8-250. Environmental Health Technician, July 1974.[f]

3) FM 10-23. Army Food Service Operations, September 1978.[f]

4) Field Interview with personnel at U.S. Army Logistics Center and U.S. Army Troop Support Agency, Ft. Lee, VA, 16 Oct 1980 (Appendix A, 4.5).[b]

5) Observation of Field Feeding, Operation Gallant Crew-77, U.S. Army Troop Support Agency, 5 May 1977.[e]

6) Field Interview with personnel at U.S. Army Natick R&D Food Engineering Laboratory Natick, MA, 10 March 1981 (Appendix A, 1.6c).[b]

*For explanatory notes a-g, see page 186.

7) Users' Meeting to Discuss the Field Sanitation and Water Problem Definition Study, Aberdeen Proving Ground, Edgewood, MD, 5/18/81. (Appendix A, 1.9)[b]

DATA GAPS AND RESEARCH NEEDS

1) Methods for reducing water requirements for cleaning, cooking and serving utensils are needed, especially in water short areas, e.g., use of teflon coatings in cooking pots.

2) A positive technique and procedure is needed for disinfecting utensils in the field.

3) There is a need to protect cooking utensils and equipment against contamination from sand, dust, etc., especially in arid regions.

4) A design for a field expedient washing sink (under consideration by Natick Lab) is required to facilitate the cleaning of large cooking pots and serving containers and utensils used in the fields.

5) Criteria should be developed for design of a field improvised 55-gallon sink and compatible water heater.[7]

TOPIC 5: Food Service Operations - Mess Kit Cleaning and Sanitation

Situation: *Operational Environment - All Climates*
Operational Characteristics - Individual Soldier

REQUIREMENTS

Criteria:

1) The individual mess kit should be washed immediately after use.

2) The mess kit should be allowed to air dry and be properly stored where it won't get dirty.

3) Boiling water should be available for precleaning mess kits prior to food service.

Procedures:[1]

1) A 32-gallon can is filled with water and heated to boiling temperature for use as a precleaner for mess kits.

2) After eating, the soldier scrapes food scraps from mess kit into a garbage can, pit or trench.

3) A mess kit laundry is established, consisting of a row of three 32-gallon cans - the first contains hot soapy water for washing, the second is a rinse to remove suds, and the third contains boiling water for a final rinse of at least 30 seconds. (One laundry will clean the mess kits for 80 soldiers.)

4) Immersion heaters are used to heat the water in each can.

5) Mess kits are allowed to air dry after cleaning.

6) When boiling water is not available, the same basic procedure is employed using cold water, except that the final rinse contains a chlorine-iodine disinfectant solution.

Effectiveness:

1) The cleaning procedure is dependent on mess personnel conscientiously providing operable mess kit laundry facilities.

2) Immersion heaters must be regularly maintained and supported with spare parts to provide a continuous supply of boiling water.

3) In cold water, trichlormelamine disinfectant (Disinfectant Food Service MIL-D-11309E) can be used to clean mess equipment.[2]

Field Experience:

1) The above procedures have been employed for mess cleaning in the field since World War II.

2) During FTX Reforger 79, about 10 percent of the 52 units inspected were found to have inadequate mess kit washing practices.[3]

3) "Mess kits were utilized by the majority of the units. In several instances, plastic trays were carried to the field. Only one unit was observed utilizing disposables, which were available for officer personnel and guests. Problems resulting from the utilization of the mess kit were primarily associated with mess kit laundry line operations. Frequently observed deficiencies include the following: an improper number of immersion heaters per line; water was not maintained at the proper temperature; There was an insufficient number of stove pipes used with immersion heaters to create proper draft; mess kit laundry lines were being used to wash pots and pans; mess kit lines were not frequently relocated to eliminate muddy conditions; personnel were frequently unfamiliar with proper field washing procedures; equipment was stored on the ground; 32-gallon cans for mess kit lines were often excessively soiled and water was not frequently changed when soiled; stove pipes were in disrepair; and food service disinfectant was not available for emergency washing operations. In many instances a predip was not used; when used, the predip water frequently was not boiling".[4,7]

Field Interviews:

1) New methodologies for mess kit washing in field bivouac areas should be explored.[5]

2) The current mess kit needs to be redesigned to facilitate cleaning and reduce water demand for cleaning purposes. At the U.S. Army Natick R&D Labs hard-coated surfaces applied to mess kits and layers of disposal mess kit inserts are being developed as possible alternatives.[6]

3) A potential method to reduce water use and improve sanitation of mess kits would be to utilize field wipes to clean the kits.[6] Field wipes are currently under investigation at the U.S. Army Natick Research and Development Laboratories.[2]

POTENTIAL HEALTH EFFECTS

The current mess kit cleaning procedures provide potential mechanisms for transmission of disease such as hepatitis, salmonellosis, and a wide range of viral enteric diseases. The major weakness is in the improper use of immersion heaters and/or disinfectants such that the final rinse water does not kill pathogens but instead provides a media for growth and a source of contamination for every kit which is placed into it.

DOCUMENTATION*

1) FM 10-23. Army Food Service Operations, September 1978.[f]

2) Interview with personnel at the U.S. Army R&D Command, Natick, MA, 9 Dec 1980 (Appendix A, 1.6a).[b]

3) "Field Sanitation and Hygiene During FTX Reforger 79," Major J.A. Thomasino, Medical Bulletin of the U.S. Army, Europe (4 pages), volume 37, No. 3, March 1980.

4) "Observation of Field Feeding, Brave Shield 19, Fort Hood, TX," Memorandum DALO-TAD-M (8 pages), Major A.D. Carnes, 31 May 1979.[e]

5) Interview with personnel at the U.S. Army Logistic Center and U.S. Army Troop Support Agency, Ft. Lee, VA, 16 October 1980 (Appendix A, 4.5).[b]

6) Interview with personnel at U.S. Army R&D Command, Food Engineering Laboratory Natick, MA, 10 March 1981 (Appendix A, 1.6c).[b]

7) Blovin, J.D., Maj., "Observation of Field Feeding, Operation Gallant Crew - 77," U.S. Army Troop Support Agency, Fort Lee, VA, 5 May 1977.

DATA GAPS AND RESEARCH NEEDS

1) Numerous deficiencies in mess sanitation have been reported in recent exercises, apparently due to the lack of command emphasis and inadequate training. This deficiency should be remedied.

2) There are opportunities for improving the mess laundry by improving the efficiency of water heaters. The immersion heater is reportedly dangerous, and frequently badly utilized. Current procedures will not be very effective in cold regions. Consideration should be given to the use of a steam generator (portable) as a means of sanitizing utensils and cooking equipment. Other alternatives to the current sanitizing procedures might include a new disinfecting solution or the use of plastic inserts (disposable/peelaway).

3) Mess kit coating (e.g., Teflon) would permit easier cleaning with less water and more rapid drying. Potential problems from field use of coated mess kits should be evaluated.[5,6]

4) Plastic inserts (disposable/peelaway) are another alternative to mess laundry. Potential problems with peelaway disposable inserts should be studied. For example, failure of supplies, the impact of increased garbage disposal, revision of mess kit cleaning requirements.[5,6]

*For explanatory notes a-g, see page 186.

5) The following alternatives to the current methods for cleaning/sanitizing field mess kits that should also be evaluated:

- disposable disinfectant wipes (currently under investigation at the U.S. Army Natick Research and Development Laboratories).[2]

- Dry heat (< 212F°) air drying of mess kits following final rinse

- disinfectants in the final rinse

TOPIC 6: Food Service Operations - Mess Hall Waste Disposal (Garbage and Wastewater)

Situation: *Operational Environment - All Climates*
Operational Characteristics - Large Field Units

REQUIREMENTS

Criteria:[1]

1) Dispose of wastes promptly after generation.

2) Employ methods that will avoid attracting insects and animals (large and small) and preclude contamination of water sources.

Procedures:[2,3]

1) Liquid wastes are to be processed through a grease trap and effluent disposed of in a soakage pit.

2) Grease traps are periodically cleaned and disposal facilities sprayed with insect repellent.

Effectiveness:

1) Field expedient grease traps and soakage pits are effective except in areas where there are impermeable soils, rocky and frozen ground and in locations having a high water table.

Field Interviews:

1) Marine units training at Twenty Nine Palms, CA, found that there is a tendency for water to build up at the bottom of a soakage pit quite easily (probably due to grease accumulation reducing soil permeability). A solution adopted was to dig a shallow trench running down hill. This disposes of liquid waste by a combination of evaporation and percolation.[4]

POTENTIAL HEALTH EFFECTS

1) Garbage disposal facilities may attract flies, other insects and vermin that spread disease if incorrectly maintained.

2) Water sources contaminated with garbage and similar waste will produce disease if not adequately treated.

DOCUMENTATION*

1) AR 40-5. Health and Environment, September 1974.[f]

2) FM 21-10. Field Hygiene and Sanitation, July 1970.[f]

*For explanatory notes a-g, see page 186.

3) Preventive Medicine Technical Guide, 20th Preventive Medicine Unit (SVC) (FLD) APO 96227, 1968.[e]

4) Interview with Marine Corps Air/Ground Combat Training Center, Twenty Nine Palms, CA, 28 January 1981 (Appendix A, 5.2).[b]

5) Telephone Interview of Preventive Medicine Personnel Assigned to USAREUR, 15 April 1981 (Appendix A, 3.1).

DATA GAPS AND RESEARCH NEEDS

1) Alternative procedures are needed for the disposal of liquid kitchen wastes in areas of low permeability soils, high water table and frozen ground.[2,3]

2) Grease traps and soakage pits do not always function effectively in hot arid regions. Procedures should be developed for the disposal of wastewaters containing grease, soaps and other materials that can lower the permeability of soils.[4,5]

TOPIC 7: Food Service Operation - Food Storage & Transportation

Situation: *Operational Environment - All Climates*
Operational Characteristics - Company and Larger Size Field Units

REQUIREMENTS

Criteria:[1]

1) Prevent contamination of stored food.

2) Prevent growth of organisms which cause food poisoning or spoilage.

Procedures:[1]

1) Store pershables in ice chest or underground food box.

2) Store non-perishables in protected, ventilated location.

3) Before preparing or serving perishables, inspect for mold, rot, odor, color, slime, signs of thawed/refrozen food.

4) Inspect non-perishable dry goods for excessive moisture, greasy substances and color changes.

5) Inspect canned goods for rust, punctures, swelling and expiration date.

6) Food failing inspection should not be served.

Effectiveness:

1) Shelf life of stored food varies with climate.

2) B ration and C ration supplies are substantially packaged and provide significant protection from NBC agents. However, there is no test available to measure NBC agents in food.[2]

3) The shelf life of food after opening is not well defined.[3]

Field Interviews:

1) The Army field kitchen is not self-contained or very effective in the arctic.[4]

POTENTIAL HEALTH EFFECTS

1) Spoiled or contaminated food may cause rapid and extensive loss of efficiency or incapacity.

2) Inedible or unpalatable food may cause a loss of efficiency due to inadequate nutrition along with morale problems.

DOCUMENTATION*

1) TM 8-250. Environmental Health Technician, July 1974.[f]

2) "To Provide for Safe Subsistence Management in the CBR Environment," Special Report of Conf. conducted at Academy of Health Sciences, Fort Sam Houston, TX, 26-28 January 1981.[e]

3) Users' Meeting to Discuss the Field Sanitation and Water Problem Definition Study, Aberdeen Proving Ground, Edgewood, MD, 5/18/81. (Appendix A, 1.9)[b]

4) Interview with personnel from Cold Regions Research Laboratory (CRREL), Hanover, NH, 18 Dec 1980. (Appendix A, 1.1)[b]

DATA GAPS AND RESEARCH NEEDS

1) The use of food storage maps (correlates shelf life with storage conditions) to avoid service of spoiled/contaminated food) should be investigated.

2) The character and quality of the food ration should be matched with the needs and capabilities of the Field Food Service.[3]

3) At present, food contamination by NBC agents cannot be measured. Methods to detect NBC agents and other opportunity poisons should be developed.

*For explanatory notes a-g, see page 186.

D. Medical Wastes

Introduction

Medical wastes, while small in quantity by comparison with other field wastes, can contribute to both health and morale problems. Pathological, infectious and patient wastes must be properly and completely disposed of to avoid potential sources of disease. On the other hand, certain types of medical equipment, such as syringes and excess or overage drugs, can readily be diverted to other than medical purposes, if not properly controlled.

The means and procedures to effect disposal of these wastes are available and have been effectively used for years by the Army. If there is any potential shortcoming today, it may be deficiencies in command supervision of disposal operations under field conditions.

TOPIC 1: Medical Wastes - Disposal of Pathological/Infectious Waste

Situation: *Operational Environment - All Climates*
Operational Characteristics - Medical Field Units

REQUIREMENTS:

Criteria:[1]

1) Prompt collection, removal and disposal of pathological wastes is required.

2) Disinfection of receptacles and storage containers is performed after wastes are removed.

3) Total waste destruction capability is required.

Procedures:

1) Pathological/infectious wastes are promptly collected after generation by medical technicians using plastic bags or other suitable containers.

2) Disposal may be accomplished by incineration, burial, or ocean dumping.

Effectiveness:

1) Incineration is the optimum method of disposal.

2) Excavations for burial would require use of mechanical equipment to ensure reliable disposal.

3) Ocean disposal requires special precautions to prevent waste from being washed ashore.

4) Disposal in the Arctic can be a problem; incineration or ocean disposal appears to be best solution.

Field Experience:[25]

1) A combination of burial, incineration, and ocean disposal was employed in Viet Nam.

2) The current Army definition of infectious waste is not practical and is causing disposal problems now[3].

Field Interviews:

1) Current policies and procedures for disposing Army hospital waste are inadequate[3;4]

POTENTIAL HEALTH EFFECTS

1) Potential for spreading disease.

DOCUMENTATION*

1) AR 40-5. Health and Environment, September 1974.[f]

2) Preventive Medicine Technical Guide, 20th Preventive Medicine Unit (SVC) (FLD), Viet Nam, 1968.[f]

3) Users' Meeting to Discuss the Field Sanitation and Water Problem Definition Study, Aberdeen Proving Ground, Edgewood, MD, 5/18/81. (Appendix A, 1.9)[b]

4) Interview with Environmental Science Officer, Surgeon's Office, HQ, XVIII Airborne Corps, Ft. Bragg, NC, 16 Oct. 1980, (Appendix A, 3.4)[b]

5) Davila, R., MD. Cpt MC, "Preventive Medicine Medical Officer After-Action Report, Bold Eagle 80," US Army Medical Department Activity, Fort Bragg, NC, November 1979.[e]

DATA GAPS AND RESEARCH NEEDS

1) Ocean disposal of pathological waste may not be an acceptable disposal procedure. Definitive guidance should be provided in published medical policy documents[1,3].

2) The adequacy of disposal policies and procedures for handling Army hospital waste should be reviewed[3].

3) The definition of infectious waste should be re-examined[3].

4) Storage methods for field hospital waste should be investigated.[3]

*For explanatory notes a-g, see page 186.

TOPIC 2: Medical Wastes - Disposal of Medical Materials†

Situation: *Operational Environment - All Climates*
Operational Characteristics - Medical Field Units

REQUIREMENTS:

Criteria[1]:

1) Must not be available for unauthorized purposes.

2) Disposal must not contaminate water sources.

3) Deteriorated medical supplies must be removed from the supply system and properly disposed.

Procedures:

1) Mutilate equipment prior to disposal, e.g., break containers and crush contents.[2]

2) Effectively dispose to prevent unauthorized recovery and use[2].

3) Drugs, biologicals and reagents must be destroyed under the guidance of a medical authority.[1]

Effectiveness:

1) Requires conscientious observance of procedures by medical technicians.

2) Command supervision over medical activity is required to be completely effective.

Field Experience:

1) These procedures were successfully employed in Viet Nam and Korea.

POTENTIAL HEALTH EFFECTS:

1) Infection from improper use of syringes.

2) Aids and abets illegal drug use.

3) Illness from misuse of unauthorized medicines.

4) Deteriorated medicines will not be fully effective in curing disease or healing wounds.

---

†(syringes, empty medicine containers, overage and deteriorated drugs and medicines).

DOCUMENTATION:*

1) AR 40-5. Health and Environment, September 1974.[f]

2) Preventive Medicine Technical Guide, 20th Preventive Medicine Unit (SVC) (FLD) Viet Nam, APO 96227, 1968.[e]

DATA GAPS AND RESEARCH NEEDS:

1) The potential for increased, clinical thermometer breakage in hot climates and attendant disposal problems should be investigated.[1]

*For explanatory notes a-g, see page 186.

TOPIC 3: Medical Wastes - Human Waste Disposal and Cleaning

Situation: *Operational Environment - All Climates*
Operational Characteristics - Medical Field Units

REQUIREMENTS:

Criteria:

1) Latrine facilities must be available for patients.

2) Bedpans must be promply emptied and cleaned and made available for reuse.

3) Washing/disinfecting facility must be close to designated patient latrine.

Procedures:

1) Patient latrines are provided based on anticipated patient load. One seat hole in each patient latrine is reserved for emptying patient body waste from bedpans/urinals.

2) Bedpan/urinal washing/disinfecting facility is established in close proximity to the designated patient latrine. The wash line consists of three 32 gal. cans situated on a soakage pit, composed of the following:

   (a) Hot soapy water maintained at minimum of 150 degrees F (65 degrees C).

   (b) Clean boiling water maintained at minimum of 212 degrees F (100 degrees C).

   (C) Cold water disinfecting solution of Wescodyne (mix per label instruction) or 200 ppm calcium hypochlorite.

Effectiveness:

1) Require conscientious attention by nursing and work personnel.

2) Methods are not adequate [2].

POTENTIAL HEALTH EFFECTS:

1) Wastes and waste contaminated bedpans are a potential source of disease.

2) Lack of or the use of soiled bedpan/urinal containers can degrade patient morale.

DOCUMENTATION*

1) ARTEP 8-123. Training and Evaluation Outline (Combat Surgical and Evacuation Hospitals).[e]

2) Users' Meeting to Discuss the Field Sanitation and Water Problem Definition Study, Aberdeen Proving Ground, Edgewood, MD., 5/18/81. (Appendix A, 1.9)[b]

DATA GAPS AND RESEARCH NEEDS

1) The use of other disposable materials and methods should be studied.

2) Alternative latrine and bedpan cleaning methods need to be investigated[3].

*For explanatory notes a-g, see page 186.

E. Other Waste Products

Introduction

Among the variety of wastes and waste products that can present serious health problems to the Army in the field are many of those wastes currently regulated nationwide by the Federal Government. The primary reason for selecting those listed herein are that these wastes can be significant in quantity and present a potential for contaminating water supply sources. They include various POL products, and pesticide solutions and containers. NBC decontamination wastewaters and contaminated wastes are also identified in this section.

The proper disposal of these miscellaneous type wastes requires the application of different techniques. In the case of POL products, it appears that alternate uses should be identified rather than resorting to disposal by burning. Pesticide and NBC contaminated waste disposal procedures are only superficially discussed in the current Army manuals. This is regarded as a major deficiency that should be corrected.

TOPIC 1: Waste Products - Contaminated and Used POL Products

Situation: *Operational Environment - All Climates*
Operational Characteristics - Mechanized field Units

REQUIREMENTS

Criteria:

1) Avoid contamination of water supplies and camp environment during disposal.

2) Recover for recycling when feasible.

Procedures:

1) Drain engine oil and other fluids (hydraulic, brake fluid) from vehicles into containers.

2) Test bulk fuel supplies (gasoline, diesel, JP 5, etc.) for contamination and remove contaminants when possible.

3) Dispose of contaminated POL products to prevent accidental use in equipment.

Effectiveness:

1) Dependent on the availability of empty containers needed for collection and disposal.

2) Requires command attention and leadership to effect proper disposal or recovery.

Field Experience:

1) No reports on field experience identified.

2) Critical nature of oils and fuels can be expected to promote command emphasis on recovery and reuse of these fuel products.

POTENTIAL HEALTH EFFECTS

1) Oil in source water fouls filter and ROWPU elements, requiring that they be replaced.

2) Contamination of surface water and groundwater sources precludes their use as potable water supplies without extensive treatment.

DOCUMENTATION*

1) Telephone Interview of Preventive Medicine Personnel Assigned to USAREUR, 15 April 1981 (Appendix A, 3.1).[b]

*For explanatory notes a-g, see page 186.

DATA GAPS AND RESEARCH NEEDS

1) There are potential uses of used engine oil and contaminated fuels in a theater of operations. The feasibility of using used engine oil in burn-out latrines should be evaluated.[1]

TOPIC 2: Waste Products - Pesticide Disposal (containers and bulk solutions)

Situation: *Operational Environment - All Climates*
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:[1,2,4]

1) Pesticides are toxic to humans and their usage must be regulated.

2) Application and disposal of pesticides should be under the direction of medical personnel.

3) Only pesticides registered by USEPA will be used by the Army.

Procedures: [1,2,4]

1) Mixing procedures are provided on bulk containers.

2) Mix only the amounts required for use.

3) Triple rinse empty containers, crush and bury to effect proper disposal.

4) Individual pesticide spray cans are to be buried rather than burned along with trash.

5) Bury full and empty pesticide containers in locations that will not contaminate ground or surface water.

Effectiveness:

1) The above procedures are prescribed by EPA and have been accepted by the Army for use at permanent installations.

Field Experience:

1) Herbicide Orange (2-4-5T) used in Vietnam is alleged to have caused a variety of health problems among soldiers who handled the herbicide and who were stationed in areas where it was applied.

POTENTIAL HEALTH EFFECTS

TM 5-632, Chapter 6, briefly discusses the toxicity of various classes of pesticides.[3] Many pesticides have acute and cumulative toxicity. With various inorganic and chlorinated hydrocarbon pesticides there is also a risk of cancer due to chronic exposure.

DOCUMENTATION*

1) AR 40-5. Health and Environment, September 1974.[f]

2) AR 200-1. Environment Protection and Enhancement, January 1978.

3) TM 5-632. Military Entomology Operations/Handbook, 1965.[f]

4) TM 8-250. Environmental Health Technician, July 1974.[f]

5) Telephone Interview of Preventive Medicine Personnel Assigned to USAREUR, 15 April 1981 (Appendix A, 3.1).[b]

DATA GAPS AND RESEARCH NEEDS

1) AR 40-5 should be updated and expanded in regard to policies and procedures for the disposal of pesticide containers and products. Information currently provided covers only permanent fixed installations. Other documents that require updating include TM 5-632 and TM 8-250.[5]

*For explanatory notes a-g, see page 186.

TOPIC 3: Waste Products - Disposal of NBC Decontamination Wastewaters and Contaminated Wastes and Objects

Situation: *Operational Environment - All Climates*
Operational Characteristics - All Field Units

REQUIREMENTS

Criteria:

1) Dispose of cleaning solutions contaminated with NBC agents where troops and local inhabitants cannot come in contact with them

2) Waste cleaning solutions must not drain into usable water supply sources.

3) Collect contaminated solid wastes and contaminated objects in an isolated area and store until final disposal can be effected.

Equipment/Procedures:[1,3]

1) Personnel, clothing, equipment and facilities may be washed with soapy water; treated with various chlorine compounds, specially formulated decontaminating solutions, or cleaning agents, e.g.,

   Chemical agents: Super Tropical Bleach
   DS2 (STB)
   DANC Solution
   Caustic Soda
   Calcium Hypochlorite
   Washing Soda
   Organic Solvents

   Biological agents: BPL
   Formalin
   Ethylene Oxide
   STB
   DANC
   Calcium Hypochlorite

   Radioactive waste: Chelating Agents
   Organic Solvents
   Caustics
   Acids

2) Liquid cleaning wastes are controlled by directing flow into a sump located in an isolated area.

3) Drainage areas, ditches and sumps may be covered with soil to contain contamination.

4) Radioactive disposal areas are marked with radiological contamination markers and location of area reported to higher headquarters.

5) Waste products and contaminated objects that cannot be decontaminated may be buried.

6) Organic solvents may be used for limited decontamination of essential equipment in freezing temperatures; wastes are collected and contained to prevent further contamination.

Effectiveness:

1) Extent of decontamination will be affected by the availability of water.

2) Initiation of CW & BW decontaminating procedures is dependent on the ability to detect and identify the type of agent.

3) Decontamination in arctic regions is limited to essential equipment and personnel when temperatures are below 32 degrees F.

Field Experience:

1) None identified.

POTENTIAL HEALTH EFFECTS

NBC agents can have the following effects on personnel:

1) Nerve agents, cholinesterase inhibitors (see Section III C, Topic 1).

2) Mustard and blister agents: cause respiratory system damage.

3) Biological Agents: cause illnesses dependent on biological agent employed (see Section IIIC, Topic 3).

4) Nuclear fallout or blast exposure will cause radiation sickness.

DOCUMENTATION*

1) TM 3-220. NBC Decontamination, November, 1967.[f]

2) FM 31-71. Northern Operations, June 1971.[f]

3) TM 10-280. Field Laundry, Bath, and Clothing Exchange Operations, July 1973.[f]

*For explanatory notes a-g, see page 186.

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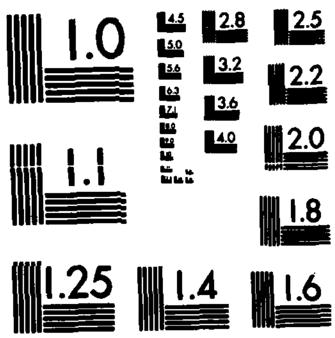

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DATA GAPS AND RESEARCH NEEDS

1) Specific and detailed procedures are needed for the proper disposal and decontamination of NBC contaminated washwaters and contaminated solid wastes and objects, particularly for hot-arid and arctic regions.[1,2]

2) The extent to which the elevated temperatures in hot, arid regions will aid in the decontamination of equipment and clothing contaminated with NBC agents should be evaluated.

3) Ethylene glycol, when added to water, may permit decontaminating operations under arctic conditions. If so, formulations should be documented. Other additives which may be more suitable than ethylene glycol should also be investigated.

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