01 Water, Sanitation & Health

Water supply and safe disposal of human wastes are most important for the protection of health. Table 1 shows human's lines of defence against diseases. It may be observed that water supply, sanitation, waste management provides human's first line of defence.

Table.1 : Human's line of defence against diseases

I. Environmental Management : Human's First Line of Defence against Diseases • Safe water supply* • Natural water quality management* • Proper human waste disposal* • Solid and hazardous waste management* • Rodent and insect control* • Food sanitation* • House sanitation* • Recreational sanitation* • Occupational health practice • Air pollution control • Noise control • Radiation control • Environmental safety and accident prevention • Land use management • Environmental planning*
II Public Health : Humans Second Line of Defence against Diseases • Nutritional level • Personal Health and hygiene practice* • Routine health check-up
III. Preventive Medicine : Human's Third Line of Defence • Phagocytosis (a natural process) • Immunity (natural and induced)
IV. Curative Medicine : Human's Fourth Line of Defence against Diseases • Administering medicine and radiation • Surgical intervention • Corrective therapy

- Water and waste related lines of defence

The high rate of incidence of diarrhoeal diseases and infant mortality in developing countries is attributed to lack of waster supply and sanitation. Every year 3 million children under five years' of age die of diarrhoea in developing countries. Every child in the third world countries suffers an average of thice diarrhoeal attacks a year. Fig. 1 shows a good correlation between infant mortality and sanitation coverage in developing countries produced by the World Health Organisation in 1981.

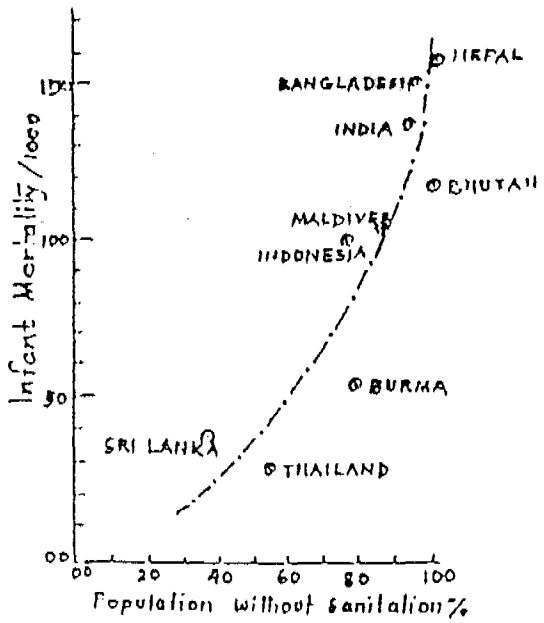


Fig.1 Infant mortality and sanitation coverage in selected south east Asian countries (WHO,1981)

The uncontrolled waste is the focal point of pollution of the environment. If the environment is polluted, it ultimately affects the population. The different routes of transmission of diseases and the interventions against such propagation of diseases have been shown in Fig. 2.

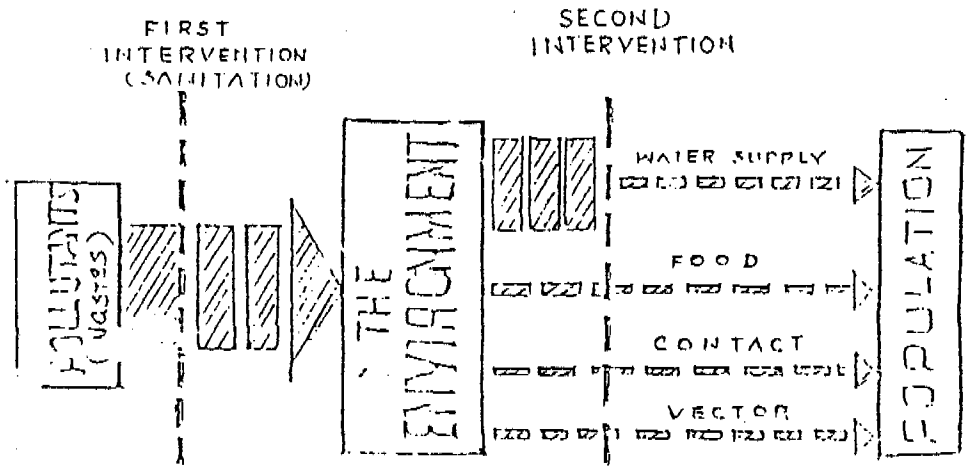


Fig. 2 Routes of propagation of Diseases and interventions

A model showing dose-response relationship of a community under varying exposure of enteric pathogens has been shown in Fig.3. The model shows that incidences of both mild and severe diarrhoea are low if the dose is low and remain constant upto certain ingestion of enteric pathogens. The incidence of both mild diarrhoea increases with the increase in dose and then it becomes constant. The incidence of severe diarrhoea also increases with the increase in the ingested dose of enteric pathogens and it also becomes constant at a relatively higher dose.

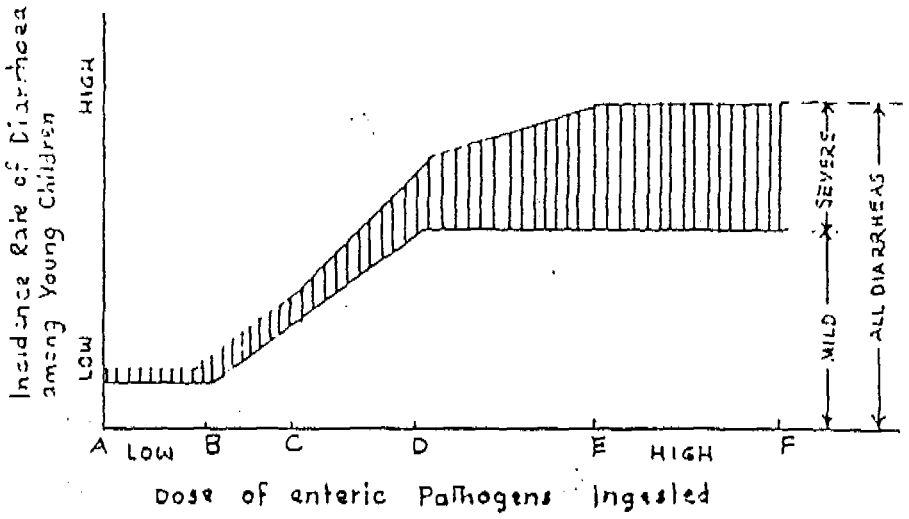
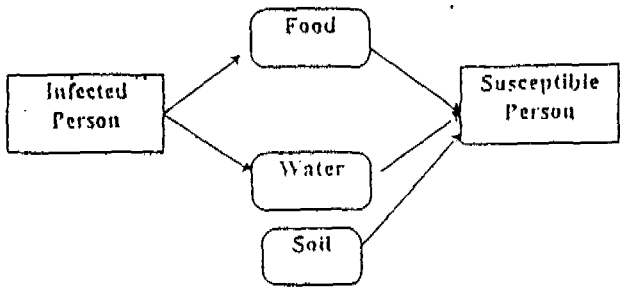
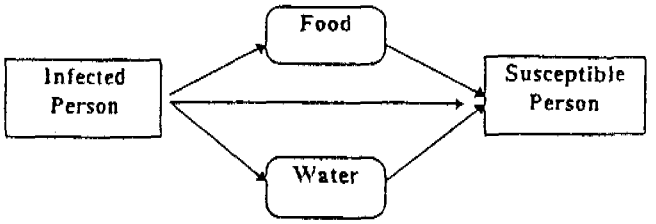
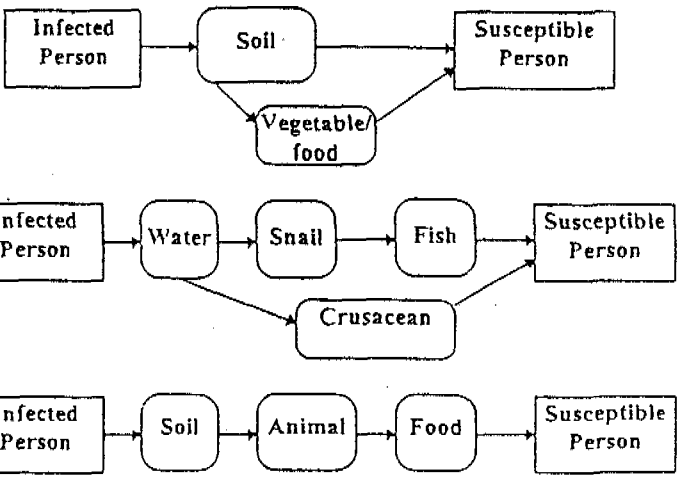


Fig.3 : The dose-response relationship under varying exposure to enteric pathogens (Esrey et al, 1985)

The diseases related to water supply, sanitation and waste management may be classified into five groups according to their transmission routes. The detailed transmission routes of these five groups of diseases are shown in Table 2. The table presents a list of diseases related to water and wastes and a clear picture of modes of propagation of these diseases.

Table 2: Transmission Routes of Water and Waste Related Diseases.

GROUP	DISEASES	TRANSMISSION ROUTE
I	Diarrhoeal Diseases: • Cholera • E.Coli Diarrhoeas • Viral Diarrhoeas • Other Diarrhoeas Dysenteris: • Amoebic dysentery • Bacillary Dysentery Enteric Fever : • Typhoid • Para-typhoid	

GROUP	DISEASES	TRANSMISSION ROUTE
II	Viral Diseases • Poliomyelitis • Hepatitis-A	
III	a. Worm Infection with no intermediate host: • Ascaris (round worm) • Hookworm b. Worm Infection with aquatic host: • Schistosomiasis • Guinea Worm c. Worm Infection with animal host: • Tape Worm	
IV	Water/Waste related insect-borne diseases: • Malaria • Dengue & Yellow Feber • Kalazar • Filariasis • Sleeping Sickness	
V	Skin, Eye and other diseases: • Skin Infection • Scabies • Eye Infection • Louse-borne typhus	

The infectious diseases are transmitted by various pathogens (disease producing microrganisms) present in human excreta. The four types of pathogens that cause diseases are viruses, bacteria, protozoa, and parasitic worms. The excreted pathogens exposed to the environment survive and sometimes mature to infect the new victim through different routes. The survival of many pathogens depend on the time and temperature as shown in Fig.4. It is evident from Fig.1 that human faeces should be kept in confined environment at least for a period of 1 year to destroy most of the pathogens. This period is also considered adequate to stabilise the organic pollutants present in human excreta into simple compounds.

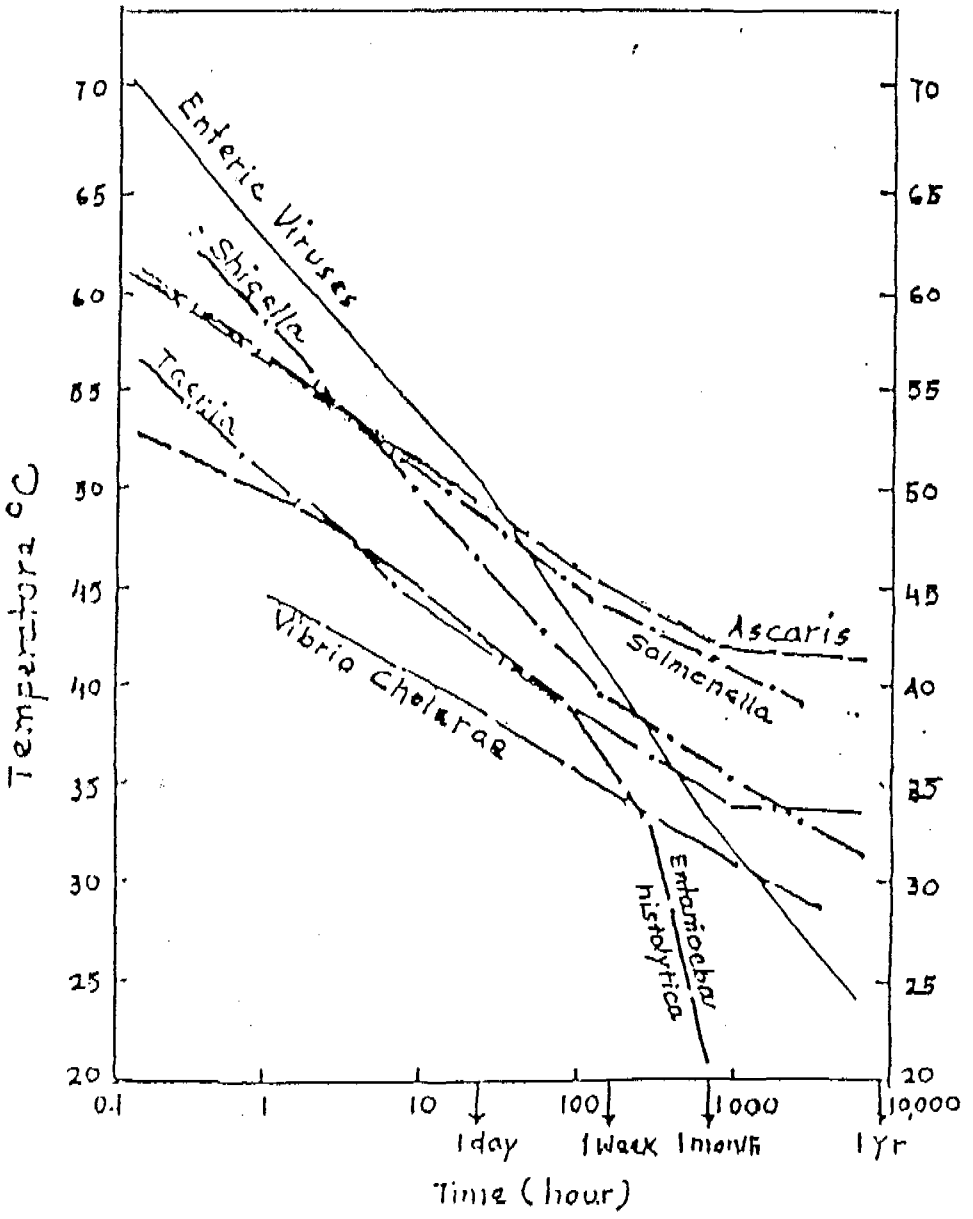


Fig. 4 : Influence of time and temperature on selected pathogens present in night soil and sludge (Feachem et al, 1981)

The percentage of diarrhoeal diseases in Bangladesh is shown in Fig 5.

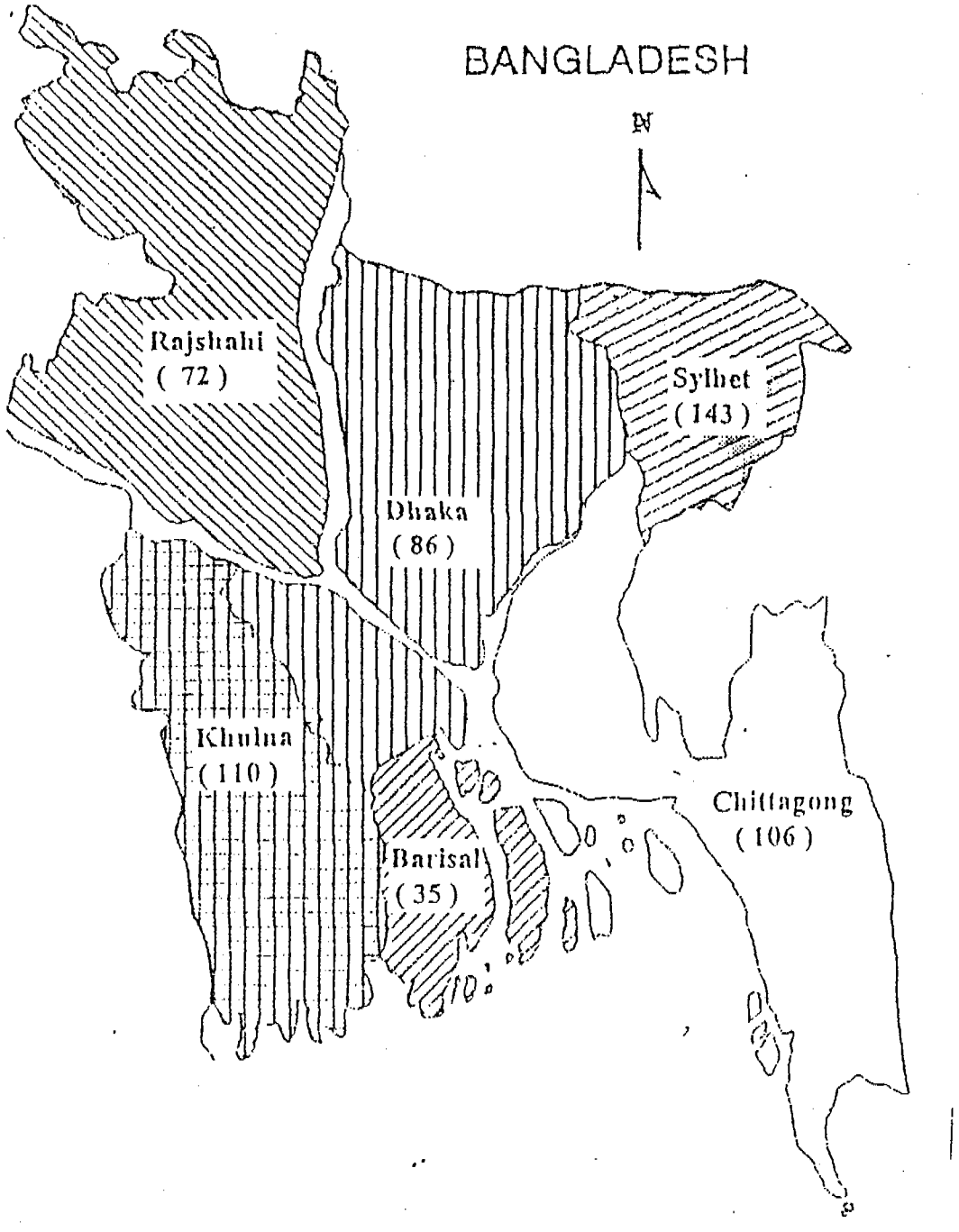


Fig. 5 : Prevalence of Diarrhoea in Bangladesh (Weekly Independent, 16 May 1997)

02 Appropriate Technologies in WSS

Definition

It is very difficult to find out a common definition of appropriate technology, which is accepted all over the world. Different agencies have their own approaches in defining the term. Some of them are :

Definition by ILO

ILO considered appropriate technology as:

- It has big capacity to expand employment.
- It firmly associates with local industry and meets a demand from the market.
- It needs small investment corresponding to the local income level.
- It can use local resources.
- It has higher productivity compared to that of traditional local technology.
- Its maintenance is easy.
- It is socially acceptable.

Definition by World Bank

An appropriate or alternative technology must:

- be effective : do whatever task it is designed to accomplish,
- be convenient : so people will be encouraged to use it,
- be acceptable to users : it should not conflict with people's beliefs and customs,
- use local materials and skills : a major way to lower costs and get people involved,
- be easily maintained : to avoid long breakdowns and allow local people to fix equipment.
- be adaptable : so it can be improved or modified to suit changing conditions,
- be affordable : so people will be encouraged to install the technology.

Definition by WHO

The appropriate technology element for water supply and sanitation is characterised by :

- Socio-cultural appropriateness,
- affordability,
- ease of maintenance with the skills available in the agency or community,
- maximum use of locally available materials or spare parts,
- easily understood attributes,
- technical efficiency.

Criteria for appropriate technology:

From the above definitions it may be said that appropriate technology should satisfy the following criteria.

- Employ local skills.
- Employ local material resources.
- Employ local financial resources.
- Be compatible with local culture and practices.
- Satisfy local wishes and needs.

Selection of appropriate technology

Selection of an appropriate technology for a certain development project for a certain area is literally a very difficult job. It must come from the extensive experience and research. However, a list of principal actions which must complement standard practice to accelerate progress in providing water and sanitation services includes:

- Particularly careful attention must be given to the proper balance among water supply, waste disposal, and hygiene education.
- Results in research in appropriate technology must be disseminated to all to help them consider and analyse the alternatives of meeting the demands of the few at high standards or meeting the basic needs of the many at simple standards.
- Institution-building efforts should be strongly oriented toward the development of institutions and institutional hierarchies that can reach large numbers of communities and beneficiaries effectively.
- Increased attention should be given to the training of staff in developing countries for improvement of water supply and sanitation - not only technical and commercial personnel, but also promotion, health and extension works.

The process of selecting the appropriate technology begins with an examination of all of the alternatives available for improving sanitation. There will usually be some technologies that can be readily excluded for technical or social reasons. For example, septic tanks requiring large drainfields would be technically inappropriate for a site with a high population density. Similarly, a composting latrine would be socially inappropriate for people who have strong cultural objections to the sight or handling of excreta. Once these exclusions have been made, cost estimates are prepared for the remaining technologies. These estimates should reflect real resource cost, this may involve making adjustments in market prices to counteract economic distortions or to reflect development goals such as employment creation. Since the benefits of environmental factors in the community that act as disease vehicles and recommend improvements that can help prevent disease transmission. The final step in identifying the most appropriate sanitation technology rest with the intended beneficiaries. Those alternatives that have survived technical, social, economic, and health tests are presented to the community with their attached price tags, and the users themselves decide what they are willing to pay for.

Key factors for appropriate technology:

Some of the key factors need to be considered for different WSS facilities are shown in the table below:

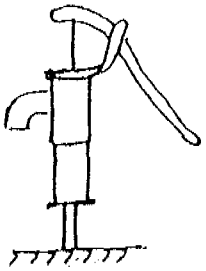
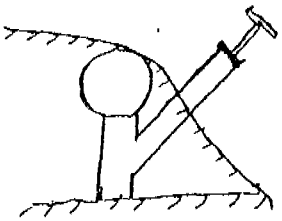
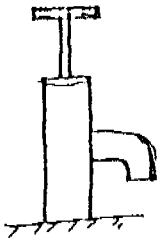
KEY FACTORS	WATER SUPPLY	SANITATION
Technical	Availability of source of water Hydro-geological conditions Design of technology Capacity/output Installation cost Quality of materials Availability of Skill Availability of spare parts Cost of spares	Ground condition Design of technology Users number Installation cost Quality of materials Availability of Skill Location / site Source of water
Social	Ability and willingness to pay User friendliness Ease of operation Ease of repair and maintenance Operation cost Maintenance cost	Hygiene education Motivation to use Privacy Super structure Defecation habit Religious sanctions

TECHNOLOGICAL OPTIONS IN WATER SUPPLY AND SANITATION

1. Water Supply

Drinking water supply in Bangladesh is based on ground water sources. Ground water is free from pathogens and require no treatment for domestic water supply. But ground water is rich in dissolved salt specially dissolved iron and hardness in ground water in relatively shallow aquifer is quite high which restricts the other domestic uses of tubewell water. The most common technologies used for the abstraction of water in Bangladesh are No.6 pump in high water table areas, Tara pump in low water table areas and in some very high water table areas Rower and Treadle pumps are used. Open dug wells are also used in some areas for domestic water supplies. The performances of No.6, Tara and Rower pumps are compared in Table 1:

Table 1: Comparison of different types of manually operated pumps used in Bangladesh

Parameters Compared	 No.6 Pump	 Rower Pump	 Tara Pump
Type	Suction Pump	Suction Pump	Force Pump
Stroke Length	240 mm	980 mm	300 mm
Hydrodynamics	Inertia effect exists	Inertia effect partially eliminated	Inertia effect exists
Lift	1 - 8 m	1 - 8.5 m	10 - 15 m
Flow	0.40 - 0.69 l/s 0.84 - 1.40 l/c	0.45 - 0.80 l/s 1.10 - 1.60 l/c	0.55 - 0.69 l/s 0.55 - 0.69 l/c
Operation	Ergonomically logical but tiring over longer period	Ergonomically comfortable, tiring over longer period.	Ergonomically unfavourable
Life	15 Yrs.	3 - 5 Yrs.	3 - 5 Yrs.
Sanitary Protection	Reasonable protected	Unprotected	Reasonably protected
Components need frequent change	Plunger and check valve	Cup seal, check valve and surge chamber	Cup seal and check valve

There are about 2.5 million public and private handpump tubewells in the rural area of Bangladesh operating under suction mode. Analysis of ground water level reveals that the ground water table in 35% of the area of Bangladesh will be beyond suction limit in the year 2000 as compared to 25% in 1993. This will make one hundred thousand hand pump tubewells operating under suction mode inoperational. A technological shift from No.6 to Tara pump would be required to maintain the existing water supply coverage in these areas.

There are also No.4 and No.2 manually operated pumps available where discharge requirements are low. The conventional tubewells according to their depth, arrangement and special uses are also termed as:

Deep Tubewell
Shallow Tubewell
Shallow Shrouded Tubewell (SST)
Very Shallow Shrouded Tubewell (VSST)

Surface water in Bangladesh is highly polluted and needs extensive treatment for use as drinking water. The installation of treatment plants for water supply for the scattered population in the rural area is not feasible. In water quality problem areas specially in saline areas small scale experimental treatment facilities are being used for the purification of low saline surface waters for community water supply. These treatment facilities are:

Slow Sand Filter (SSF)
Infiltration Gallery (IG)

These are low cost technologies but the main problems encountered include lack of maintenance by the beneficiaries.

The small scale community type Iron Removal Plants are now being used in Bangladesh for the treatment of ground water. A few experimental units of different models have been tried and some are being used successfully. Also maintenance is the problem in the operation of these plants.

II Sanitation

There are many technological options available for on-site and off-site treatment and disposal of human wastes. Some of these options have been shown in Fig.2.

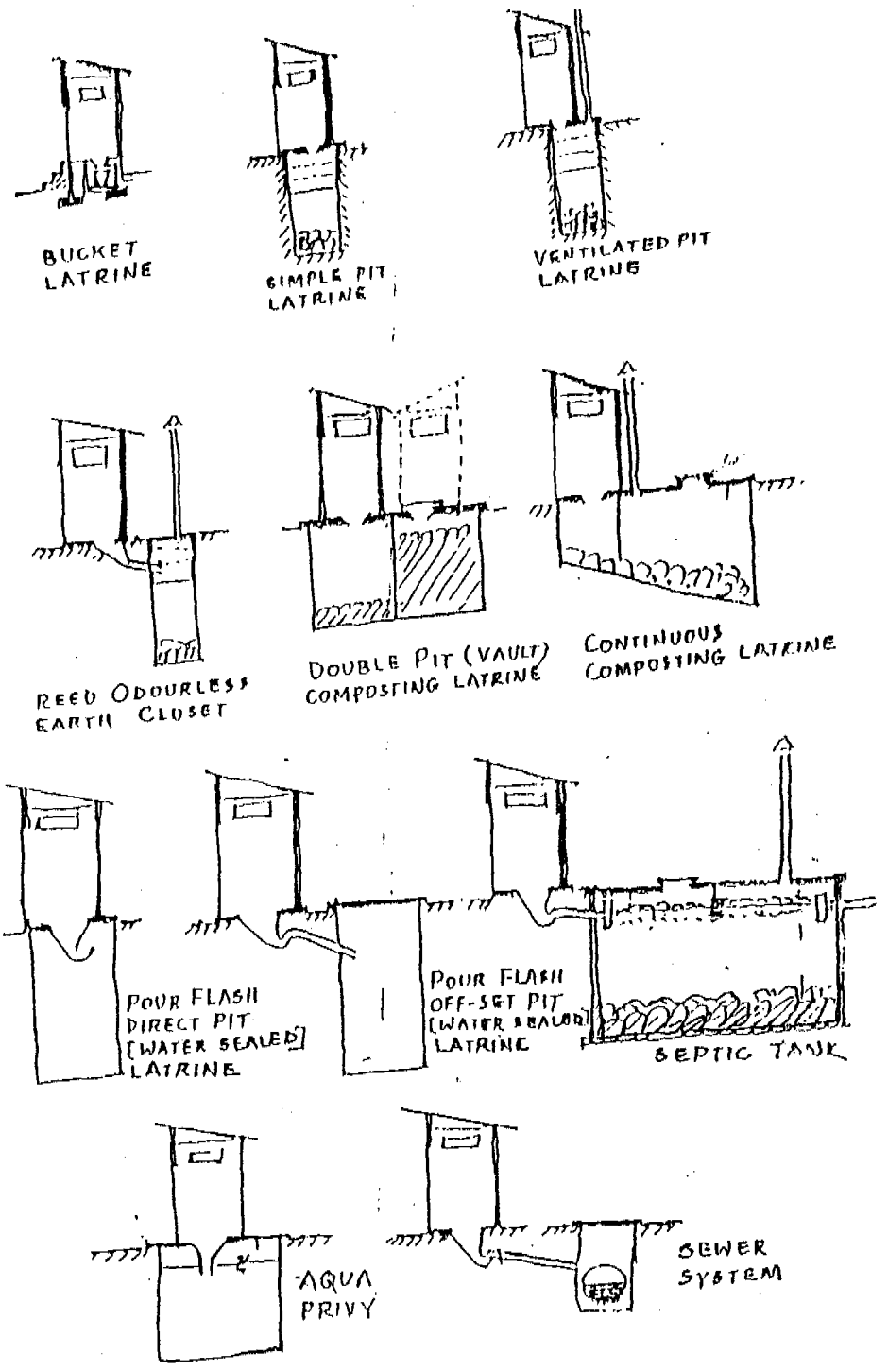


Fig.2: Alternative technological options for sanitation

The common sanitation technologies in Bangladesh are sewerage system, septic tank, sanitary pit latrines and others including home made latrines and defecation in open areas. The population coverage by different technological options is shown in Table 2.

In Bangladesh water-sealed direct pit latrine shown in Fig.3 has been found suitable for rural areas and Water-sealed offset twin peat shown in Fig.4 has been recommended for use in the small urban centres. Septic tank is the preferred option in large urban areas.

Table 2: Population coverage by different sanitation technology

Sanitation Technology	Population Coverage %				
	Dhaka	Chittagong	Zilla Towns	Thana Towns	Rural Area
Sewerage System	18	-	-	-	-
Septic Tanks	40	31	22	6	-
Sanitary Pit Latrines	15	7	16	16	18
Others	27	62	62	78	82

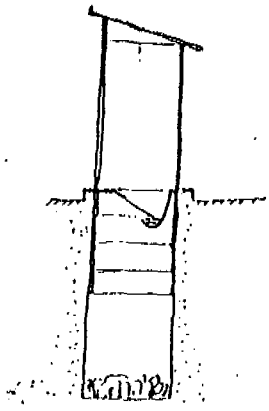


Fig.3 : Water-sealed direct pit latrine

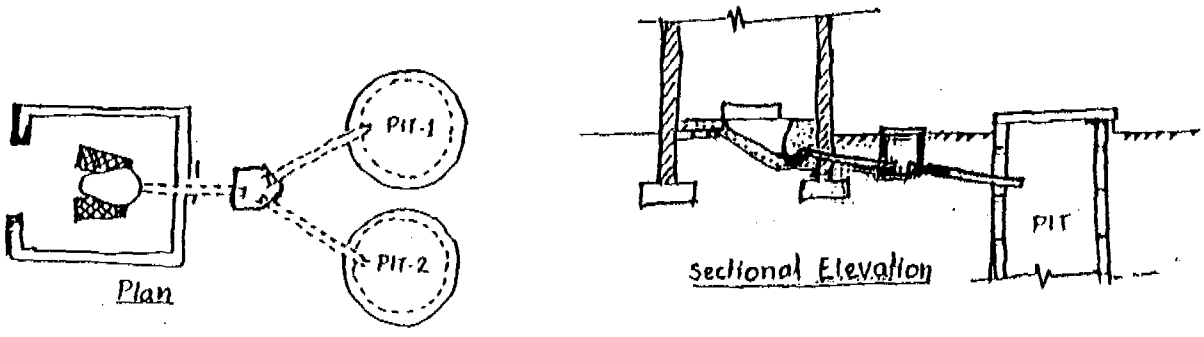


Fig.4 : Water-sealed offset twin pit latrine

Table 3: *Alternative Sanitation Technological Options*

Type	Cost	Health Benefit	Water Requirement	Status in Bangladesh
Bucket Latrine	Medium	Low	None	Available, being gradua'ly phased out
Direct Pit Latrine	Low	Low	None	Acceptable as low-cost method
Offset Pit Latrine	Low	Moderate	Water near toilet	Acceptable as lc v-cost method
Ventilated Improved Pit (VIP) Latrine	Low	Moderate	None	Tried on experimental basis
Reed Odourless Earth Closet (ROEC)	Low	Moderate	Water near toilet	Modified version adopted in limited scale
Pour-Flash, Water-Sealed direct Pit Latrines	Low	Good	Water near toilet	Accepted in rural sanitation programme
Pour-Flash, Water-Sealed Offset Pit Latrines	Medium	Very Good	Water near toilet	Accepted in municipal sanitation programme
Double Vault Composting Latrines	Medium	Low/Moderate	None	Tried on experimental basis, but not accepted
Continuous Composting Latrine	Medium	Low/Moderate	None	Not available
Aqua Privy	High	Good	Water near toilet	Not available
Septic Tank and Soak Pit	High	Very Good	Piped or enough water	Widely accepted in municipal sanitation
Small Bore Sewer (SBS) System	Very High	Very Good	Piped water supply	Designed but not yet implemented
Conventional Sewer System	Very High	Very Good	Piped water supply	Available in Dhaka only

The comparison of different alternative sanitation technological options in respect of cost, health benefit, water requirement and status in Bangladesh has been shown in Table 3.

03 Socio-economic aspects of Water Supply and Sanitation

A. Socio-economic situation of Bangladesh

1. Introduction

The socio-economic factors of an area, a community or the country as a whole, are considered very much essential elements in planning and designing the development projects. Development efforts obviously target a section of people, a particular community or area based masses. It is ,therefore, is an urgent issue to know the clientele's socio-economic status, need of the clienteles, demands of them, their absorptive capacity, the gender issues involved and the potential adverse impacts on vulnerable groups. If these factors are known to the planers, decision makers and project designers, it becomes easier to set the project goal, target and strategic approaches.

Socio-economic aspect ranges a wide area to cover, however, as the course materials we will be limiting to some of the general features of the whole aspects. Remembering the central theme of the course, information and data in this lecture note have been reflected by and large around the WatSan. issues.

2. Socio-economic profile of Bangladesh

2.1 Economic

With an area of only 144,000 square kilometers and a population of 111 million, Bangladesh is one of the most densely populated countries of the world (UNDP 1993). In this semitropical, predominantly rural country about 48% of rural and 44% of the urban population live below the poverty line, a reduction by almost half from 15 years ago (BBS 1993). Per capita Gross National Product in 1993 was US$220 (World Bank 1993). Households spend 59% of their income on food, and 60% of children below 5 years of age are malnourished (World Bank). The country ranked 147 out of 173 countries in the world as per UNDP human development index.

The annual growth of the Gross Domestic Product in the 1980-91 period exceeded the population growth rate and averaged 4.3%, an increase from 2.3% in the previous decade (Word Bank 1993). While agricultural production averaged 2.6% growth annually during that period, its share shrank from 55% to 36% of GDP, while industry grew from nine percent to 16% and services from 37% to 48% (World Bank 1993).

2.3 Demographic Trends

The population in 1996 was approximately 111 million, and expected to grow to 131 million by the year 2000. Already an estimate shows that it has further increased to 121.8 million of which 62.4 million male and 59.4 million female(estimated as on January 1996)*. The overall growth rate has dropped from 2.7% in 1970-1980 to 2.2% between 1980-1991 and 1.84%(estimated as on January 1996)*. The urban population has been growing faster than the rural population due to migration, increasing from eight percent of the population in 1970 to 17%, or 21.6 million people, by 1991 (World Bank 1993). About 48% of the urban population live in Dhaka, Chittagong, Khulna and Rajshahi, and 40% live in the 108 Pourashavas.

2.4 Education

As per recent BBS publication, 95 literacy rate stands for Bangladesh at 44.3% (male 50.4% and female 28.5%) and the adult literacy rate(15+) is 48.6% (56.3% male and 39.4% female). 80% primary school aged children are enrolled in school but only 40% complete the cycle. Though a higher proportion children are now being enrolled in primary education, attendance is no more than 50%. After dropping out of school, uneducated children grew into illiterate adults and thus the cycle is repeated.

2.5 Emergencies

Bangladesh has a reputation for being disaster prone. Floods, cyclone, tornadoes and draughts strike with depressing regularity and intensity. 1657 lives were lost in the flood of 1987, 2379 in 1988 and 5780 in the cyclone of 1988 and 138, 868 in 1889. The cyclone of 1991 alone caused damage to $2.4 billion.

2.6 Water supply, sanitation and health

At present, more than 90% of the rural people have access to a tube-well with 150 metres of their homes compared to only 40% in 1981. About 95% of the people drinks tubewell water. About 44% of the rural population uses sanitary latrines compared to less than one percent in 1981. People are now latrine conscious with 61% using some form of latrine. Overall urban water supply coverage has risen from 26% in 1981 to 47%, and sanitation from 20% to 42%.

The health status of this poverty stricken country is appallingly poor. Infant mortality rate persists at a high level with 77 deaths per 1000 live births in 1995 (MOH&FW, 1996). Water related diseases still remain a common occurrence in Bangladesh despite significant improvement in drinking water supply and sanitation over the past decade. Number of deaths due to diarrhoea diseases alone stands at 230,000 annually and in 1992 some 6.9 million cases of diarrhoea diseases have been reported (MOH&FW, 1994).

Although adequate supply of safe drinking water and provision for proper sanitation is extremely important for the reduction of mortality due to waterborne diseases, yet mere access to these facilities may have little impact on health in the absence of other factors influencing their use. Bangladesh has made tremendous strides in improving access to safe drinking water. Sanitation coverage has also increased significantly. Yet the impacts of these interventions in terms of improved health have been very modest.

Experience of the International Drinking Water Supply and Sanitation Decade (1981-90) have indicated that physical provisions of services are not a sufficient pre-condition for improvement of health. Community involvement, hygiene education and social mobilisation are identified as indispensable for water and sanitation services to be effective.

2.7 Water Conditions

Bangladesh is a fertile deltaic region criss-crossed by numerous rivers and subject to periodic and occasionally catastrophic flooding. The hydrology of Bangladesh is characterized by three major international rivers: the Brahmaputra, the Ganges and the tributaries forming the Meghna. Surface water availability varies by region according to rainfall and storage capacity in streams, ponds and lakes. About 37% of the country is permanently or intermittently inundated during the monsoon up to a depth of 30 cms or more.

Sand and clay soils which predominate in the country provide a natural filter which rapidly attenuates bacterial contaminants and creates a vast reservoir of potable groundwater for relatively cheap extraction. Although well water is favoured for drinking, surface water is the traditional and more convenient source of supply for other uses, and much is polluted with human waste (World Bank 1990).

Despite the country's relatively small size, water availability and quality vary and tubewells are not distributed evenly among the regions. In the north, usually spared the severe flooding of the south, groundwater tables are generally shallow but not overly close to the surface. Under these conditions handpumps and latrines are suitable technologies and tubewell coverage is approximately 85% (UNICEF 1993c). Low water tables are becoming more common, from 8% of the country in 1985 to an estimated 50% by the end of the century (UNDP 1991). In the coastal areas, upper aquifers are often saline, usually requiring deep tubewells to reach sweet water, although some potable pockets of shallow aquifers have been tapped with handpumps (GOB-Netherlands 1986). These areas are also underserved. Annual flooding poses a difficult problem for sanitary latrines.

2.8 Food

In 1993 food production was at an all-time high, price was low and the country was virtually self-sufficient in rice. But millions still went hungry. Around 30 million Bangladeshies can not afford even 1805 calories per day (20% less than the daily prescribed intake). Since 1972 the average price of rice fallen by around 30% enabling many families to by enough food. There was a particularly sharp drop between 1991/92 and 92/93 when it fell by 16% and at that time rice consumption increased by 38%.

Poor Bangladeshies have to spent cent percent of their income for daily food consumption (69.7%) of which 41.8% for cereals and 18.5% for protein rich food while vegetables and fruit constitute 16.6%. (BIDS, 1989/90.

3. Women, Water and Sanitation

Women are the prime beneficiaries of water and sanitation projects. It is their productivity and their impact on family health which are most affected by improved access to clean water. Understanding their needs as managers and as water users is important to program success. However, gaining this understanding requires conscious effort to reach women and involve them in projects from the first step, as women operate under constraints not shared by men.

Equal rights guaranteed under the constitution are undermined by civil laws originating from a patriarchal interpretation of socio-cultural norms. Female mobility outside the home is restricted by cultural traditions. Women's status and disadvantages are consistently reflected in statistical data. Cultural practices limiting women's access to sufficient food deprives them of energy needed to meet their various responsibilities (World Bank 1990). More than half of the poor population is female (World Bank 1989). Mortality rates of female infants are higher than that of males, and life expectancy of women is lower than for men (World Bank 1993). Female children have about three times the rate of malnutrition as males (World Bank 1990). Seventy-eight percent of women are illiterate and women are paid lower wages than men (World Bank 1993).

It is women who are already investing their time and labour to bring water to the household. Projects which increase their time and labour requirements, such as projects in which fetching tubewell water is more costly in time and labour than scooping up water from a nearby surface water source, will succeed only to the extent that women see a compelling reason, and are able, to make a higher investment in water.

Women's productivity is underestimated, which consequently undervalues the labour-saving benefits of water projects. Their participation in projects and their utilisation of water and sanitation facilities must take into account the value of women's time and the opportunity costs of participation. Much of women's labour is unreflected in national income accounts as it is largely unpriced and uncompensated home-based labour (World Bank 1990). Their tasks include cooking, cleaning, washing, collecting fuel and water, rearing children, caring for the sick, raising fruits, vegetables and livestock, and processing field crop production. In 255 of rural landless families female earnings are responsible for food security. Among male-headed households with female wage earners, female earnings contribute 255 to 50% of family income (World Bank 1990). Non-recognition of their myriad contributions to the economy and household impedes informed decision-making about resource allocation in development planning.

The Fourth Five Year Plan (4FYP) recognises the importance of bringing women into the mainstream of development. Many programs administered by NGOs and community based organisations emphasise benefits for women. About 94% of Grameen Bank b3neficiaries are women, many of whom used their credit to purchase tubewells (Khandker et al. 1993). There are many NGOs, such as Banchte Shikhi in Jessore, that are founded and managed by women, These provide models for reaching women in water and sanitation programs.

The statistical demonstration of a direct relationship between water and sanitation projects and positive health impacts remains an elusive goal (Churchill 1987). Despite improvements in water and sanitation in Bangladesh, the expected health impacts have not been realised. It is likely that water, sanitation, and hygiene education are necessary but not sufficient interventions to improve health. Other important factors include rising incomes and increased education (Word Bank 1993). Therefore, while continuing to improve access to and use of water and sanitation facilities, it may be necessary to use non-health measures to assess the impacts of water and sanitation interventions to distinguish their contribution form other actions. Alternative measures may also draw attention to additional, non-health benefits of water and sanitation projects such as increased number of workdays, higher individual productivity, etc.

B. Synopsis of Social issue, it's necessity, context, Analysis and Project Design

1. Why socio-economic analysis is necessary

Socio - economic analysis is necessary to know information on the following.

- Gender
- Ethnicity
- Social impacts

- Institutional capacity

2. **Social context are considered to do what**

- **Identify key stakeholders**
  - participation in project selection, design and implementation
- **Ensure that the project objectives and incentives for change**
  - acceptable to maximum people
  - gender and other social groups are addressed
- **Social impact assessment**
  - adverse impact, degree and mitigation possibilities
- **Develop ability**
  - enable participation,
  - resolve conflict,
  - permit service delivery and
  - carry out mitigation measures as required

3. Social Analysis and Project Design

3.1 Social Analysis

3.1.1 Clientele Group(s)

- identify population expects to be served by WSS facilities
- identify the key population whose participation is a key in achievement of the project objectives (landholders, workers, business owners etc.)
- prepare a socio-economic profile of the users
  - population, sub groups
  - gender differentiation
  - *households & size*
  - single and female headed households
  - location and types of housing in the area
  - peoples occupation
  - level of income and sources
  - level of education and access to education
  - access to health services
  - social organisations
  - water user groups
  - leaders and spokesmen
  - access and utilisation of WSS services
  - payments for services if any
  - socio-cultural traditions
  - other special issues seems important

3.1. 2 Clientele Needs

- identify the existing sources of WSS
  - spring, stream, deep well, river, pond etc.
  - availability, distribution facilities, distance, seasonally, quality etc.
- assess the level of service desired
  - private house connection, public hydrant, communal bath, connection to the market, school etc.
- assess the needs improvement of the initial services
  - wastewater drainage
  - public latrines
  - health education

3.1..3 Clientele Demand

- assess the demand from the users in terms of

  - expenditures and efforts
  - quantity and quality
  - problems experienced in obtaining access to facilities
  - above all, the comparison between services and cost
- assess the ability and willingness of the users to participate in terms of
  - investing own capital
  - labour
  - undertaking responsibility for O & M

3.1.4 Absorptive capacity

- assess the extent of knowledge & influence of
  - social
  - religious
  - custom and tradition
- acceptance of the recommended hygiene practices
- need for further training and education
- assess the present status of individual/ group initiatives
- capacity of O & M
- assess the appropriateness of technologies in terms of ability of the users in operating and maintenance

3.1.5 Gender issues

- assess the differing roles & activities of men and women
- inside and outside the households activities
- usual work of men and women for water, sanitation and waste management
- assess the relative access to resources
  - public latrine
  - bathing facilities

3.2 Project Design

3.2.1 Targeting

- groups and sub- groups
- co-option
- possible method

3.2.2 Participatory development process

- from project design to O&M, the involvement of the users
- users voice in decision making
  - water sources to be developed
  - type and extent of water treatment
  - transmission and distribution
  - level of service
- based on the assessment provision for the WUAs

3.2.3 Delivery mechanism

- capability of the executing agency
- capability and knowledge of the WUAs
- alternative arrangement for execution/ collaboration (NGOs)
- other interested partners (private sector)
- NGOs working in the area and their involvement

3.2.4 Benefit Monitoring & Evaluation

- monitoring indicators
  - outputs
  - purpose
  - goals
- existing MIS
  - follow up mechanism with the community

- communication from and with the community
- specific indicator to monitor the benefit of the community

C. Development Strategy & Bangladesh

1. Strategic Issue: a Client-Centred Approach

Improving health is a prerequisite to improving welfare and raising incomes, and safe water and sanitation are necessary for good health. Yet experience has shown the failure of supply-side approaches, particularly in rural areas. Agencies whose targets are solely technical installation may achieve distribution goals without having any impact on increasing the use of those facilities. When users have little voice in obtaining services which have value to them, the result is a mismatch between what users want and what planners provide, and consequently a waste of resources as facilities fail to be accepted and maintained by users.

In rural Bangladesh, tubewell water is in great demand for drinking water and is almost universally available through private as well as public pumpsets, yet only 16% use it for their full range of water needs (Mitra 1992). Sanitary latrines, which are owned, privately rather than publicly, are less widely available, although the recent growth in demand is encouraging. Facilities which meet needs appropriately will be valued and are more likely to be used. A client-centered approach promotes greater attention among implementing agencies to providing what clients want rather tan what the agencies decide they need. A strong incentive to adopt this approach is created if clients are given the opportunity, in some cases promoted by access to credit, to pay for the services they desire. When clients choose the services according to what they want and for which they are prepared to pay, they have better incentive to use and maintain the facilities they purchase.

2. Development perspective: Bangladesh

Development programs in Bangladesh take place within the general policy framework of the five year development plans. The policies and strategies for water supply and sanitation sector development are discussed in this situation analysis in terms of the fourth Five Year Plan (4FYP). Among other things, the 4 FYP emphasises several shifts:

- a gradual shift of the public service delivery agencies from being "providers" of services to "facilitators" for clients (individuals and agencies),
- particular attention to human resource development within programs,
- bringing women into the main development streams,
- mobilisation of local resources,
- encouraging and supporting the growing contribution of the private sector to development efforts, and
- restructuring and reorienting administrative organisations to make these possible.

The above facts and information are just an eye opening to the future planers and decision makers where they will plan and implement the technical projects where WatSan. issues will be at the core of the project concept. The socio-economic status of the society, cultural behaviour, traditional thinking and way of cooping with situation, obviously are the factors to be take into consideration towards a successful project planning and implementation. Details of the socio-economic consideration in designing a WatSan project will be discussed in the technical lecture note no.14 for this course (Project Cycle Management).

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04 Community Participation in Water Supply and Sanitation

Introduction

We are presenting a report survey of sources of water for household at certain villages located in Sylhet district. The villages are Bogatipur, Kazirgaon and Saterogaon under Kotwali thana of Sylhet. The main purpose of this paper is to assess the sources of existing water supply system in the villages and its impact on the health and sanitation, with the view to improving the existing water supply. The importance of pure drinking water supply can hardly be exaggerated. A report from WHO reveals that " one hospital bed out of four in the world is occupied by a petient who is ill because of polluted water.... Provision of a safe water supply is the single most important activity that could be undertaken to improve the health of people living in rural areas of the developing world." Water related diseases kill approximately 10 million people every year. Water related diseases are the leading killers of children and infants. An estimated five million infants, every year , die from intestinal diseases before their first birth day. Bangladesh is one of the poorest countries in the world with a very high rate of infant mortality.

In our country, the existing curricula on the water supply of the universities mainly deals with technologies that are advanced and sophisticated. But our technical and socio-economic base are not yet conducive to assimilate these technological advances. The professionals and technicians often face difficulties in applying their knowledge. Without the knowledge of people participation, sanitation ; it is impossible to help villagers to understand the importance of good water for human consumption and encourage them to try to improve present supply.

In the survey work, one pioneering study on the issue of drinking water sources observes that " the rhythm of water supply in rural Bangladesh oscillates between the two extreme of abundance and scarcity" . .... The situation in rural Bangladesh is such that for four months of the year, water is in abundance and for three months of the year, there is a scarcity" (People , water and Sanitation 45/46 Spring 1979-UNICEF). As in the most of the areas in the Bangladesh monsoon rain deluge the area covered by Mogulgaon cluster from May through September. At that time , though there is abundance of water , but due to the inundation the surface water sources become dangerously polluted and contaminated. We conducted our survey during monsoon period to assess the gravity of the problem of drinking water in low lying areas like Mogulgaon.

The people of Mogulgaon cluster mainly uses for drinking from four important sources viz Pukur, Tubewell, Ringwell and stream. Principal sources is pukur, because 88% households use pukur water, 10 percent use tube well water and 2 percent use ringwell and stream.

65 percent households are within the range of 300 yards of a tubewell. Among the non-users of the tubewell – 60 percent of them do not use it because location of tubewells are considerably far from their households. 40 percent do not use because of bad taste, location too public for women to use and other reasons. Adult female usually fetches the water used by the family. 54 percent households reported to have some sort of stomach trouble at the time of survey. Table 1 presents that households are not conscious of actual cause of diarrhoea, stomach problem, 23 percent households reported that they consider 'evil eyes' as the probable cause of diarrhoea.

Table 1 : For Households with Children , Incidence of Diarrhoea among Children:

Reply	Kazirgaon		Saterogaon		Bhagatipur		Grand total	
	No	%	No	%	No	%	No	%
Yes	40	59	29	60	16	39	85	54
No	28	41	19	40	25	61	72	46
Not Appl.			6		2		8	
Total	68	100	54	100	43	100	165	100

Source: Kamal,1980.

VILLAGERS' FEELING TOWARDS EXISTING SOURCE OF WATER SUPPLY:

Respondents of Mogulgaon cluster were asked to express their feeling to existing sources of water supply on four major uses viz. Drinking, cooking, bathing and laundry. The respondents had mixed reactions on the sources of drinking water. 64 percent households were not happy with the present sources of drinking water while 75 percent households expressed their satisfaction about the present sources of cooking water and 90 percent households expressed their content regarding the sources of bathing and laundry. (see figure 1)

36 percent households those expressed satisfaction, only 10 percent of them have been drinking tubewell water. But the worthnoting statistics that emerged is that the remaining 26 percent households using surface water for drinking purposes (pupur and stream) expressed their satisfaction. One of the respondents who usually use pukur water, not only expressed his satisfaction but commented that " If my forfathers could survive without using tubewell water, why could survive without using tubewell water, why I could not survive without the same?".

SOURCES OF WATER USED IN HOUSEHOLS FOR DRINKING AND COOKING:

Ninety and 92 percent respondents are using surface water for drinking and cooking respectively. The statistics itself manifest the deplorable condition of existing water supply facilities in these villages. 88 percent households are using pukur and 10 percent households are using tubewell as their only source of drinking water and most of the households are using ringwell and stream. So far as cooking water is concerned 94 percent households are using pukur while only 6 percent is using tubewell water.

DISTANCE FROM BARI TO NEAREST TUBEWELL:

17 and 48 percent households making a total of 65 percent have tubewell facilities within the range of less than 100 yards and 300 yards respectively.

26 and 9 percent households i.e a total 65 percent households have tubewell facilities within 500 yards and 700 yards respectively.

The respondents who are not using tubewell water for drinking purposes in their households were asked to identify the principal reason for not using tubewell water from a set of structured questions. 60 percent stated that since the location of the tubewells are far from their households, women - folk find it difficult to fetch water from these. A little over one-tenth of the respondents pointed out that tubewell site being to public – the social norms inhibit the womenflok to go there for fetching water. Bad taste of tubewell water and muddy path were identified as main reason for non use of tubewell water respectively by 6 and 23 percent of respondents.

It is evident from the figure 2 that out of 89 respondents who indicated that their house holds are distantly located from the tubewell site 38 percent households considered 300 yards as great distance. Hence this statistics reveals that the location of public tubewell significantly influence the extent of use. Moreover in the rural areas, adult female usually fetches the drinking water, weather the source is inside or outside the bari. 84 households said that adult female said that adult female usually fetches the water. So the importance of the location of public tubewell can hardly be exaggerated especially in a cluster like Mogulgaon where 11 percent households do not use tubewell because of its public location.

In addition, to that 23 percent households said they could not use tubewell of maddy path. Therefore, 34 percent households are unable to use the tubewell because of its location and have to ramain content with their existing surface water source. However, overall users rate is far behind expected rate.

INCIDENCE OF DIARRHOEA AMONG THE CHILDREN :

The most important purpose of conductiong this survey was to assess the impact of water supply system on health and sanitation. 54 percent households repotred that incidence of diarrhoea at the time of survey. Figure 3 shows that 54 percent of the reported incidence of diarrhoea , 49 percent of them drink pukur water and rest 5 percent drink tubewell , ringwell and stream water.

TECHNOLOGIES IN USE IN WATER SUPPLY SYSTEM :

People need water to survive. Sources of water are surface , rain and ground. Surface water sources are rivers, pukur, streams, lakes and canals. Major sources are river and pukur. Ground water sources are dug wells, srings and tubewells. Tubewell water is considered safe.

Small scale purification is done by boiling filtration and chemical disinfections includes bleaching powder, chlorine solution and tublets ,alum ,copper sulfate etc. Filtration is effected by sand filtration and filtration jars.

For water supply, No6 suction hand pumps were used extracted water from a depth of 7 meters under the ground. In low water table areas, tara pumps were seemed to solve the problem of water table but women complained of the problems of lifting the heavy T-bar handle. Regular use of these pumps had causes as the women informed during the field visits, chest pain, abdominal pain, problems of uterus. Generally women prefered to have pipe water connection.

SOCIAL MOBILISATION/ COMMUNITY PARTICIPATION

Improvement in the accessibility of the urban poor to the basic water supply services was made through mobilising and empowering them, specially the women. This was necessary to effectively operate and manage the services at the community level. At the community level, training should be organised on the leadership, co-operation, health and nutrition. Advocacy and public awareness campaign through social mobilisation was key to achieve wider coverage and universal access of the urban poor to basic services through successful demonstration.

FOCUS ON COMMUNITY PARTICIPATION FOR SUSTENCE:

Sustainability of services largely depend on the involvement of the user community in decision making regarding the choice of technology and their willingness to pay for their preferred service options. Technological sustainability would depend on the accuracy of the orginal design and transfer of the knowledge to the community on the maintainance and repair of the system. In a

community involved provision , a collection financial capacity to operate and maintain the system needs to be worked out in advance. Decisions to be agreed upon by the user, community are levels of service charge and collection and management of the fund. A mechanism of incentives income or other benefits , need to be worked for sound management of completed facilities. Similarly the community may set rules for sanctions against bad performance.

To improve prospects for sustainability of all inputs including better operation and maintenance of the facilities there is no alternative to education and management training. Education is essential in the improvement of poor communities. The curriculum and teaching time be devised to practical needs of working children, women. The vocational training facilities with practical fields oriented would be of great benefits for professionals.

CONCLUSION:

Finally it is needless to mention that proper distribution of tubewells in relation to population and its sustainable location is of utter importance for its extensive use. Our observation reveals that water system in the area lacks both these important factors. It is evident from survey work that as far as distribution of tubewell is concerned it needs serious consideration before attempting any improving measure. It is necessary to mention that six tubewells have been installed to facilitate a number of 1353 population. Tubewell users ratio is 1:225 which is more or less compatible to government development plan. But in fact it is not so in practice.
Location of public tubewell significantly influence the extent of use. From our satistics it is already establised that in rural Bangladesh adult female usually fetches the drinking water. Considering the movements of our adjult female from our social point of view tubewells should be located in the places best suited to them. Our observation reveals that if a public tubewell is installed inside a bari gradually there is a trend of its being treated as a private property of the owner of bari and it loses public ownership.

In addition to that, little less than one-fourth (23%) of the respondents said they could not use tubewell due to muddy path. If this is so, it is expected that the users rate will increase during winter season. Moreover we have also got the information that during the holy month of Ramzan use of tubewell water also increase unusually, since muslms prefer to break their fasting with tubewell water.

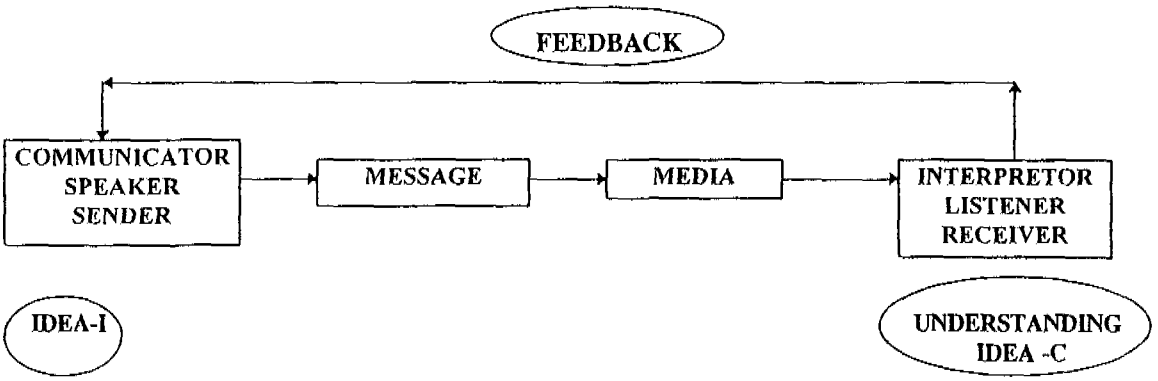
The paper gives a short account of what are the technological and socio-economic interventions and options available in the water supply in North-East zone of Bangladesh.

05 Communication in Social Mobilisation

Communication is the process of transmitting and receiving information. We can say, it is the process of conveying ideas, knowledge or message from one person or a group of person to other or many persons or vice versa. In human society, communication plays in important part in daily life. We have the advantage of language, spoken words, songs, visual aids, written scripts and so on. Besides, we can also express our feelings by facial expression and gesture of the face, hands etc. It is by communication that an individual wants himself to be understood by others. A deaf mute can communicate by signs and gestures. A normal person can communicate in many ways. It is only a literate person who can take advantage of written communication. Therefore, there are many ways of communicating and interacting. It includes both verbal and non-verbal.

Communication process:

Communication has been defined as the transfer of an idea from one person to another. The idea in the mind of the transmitter, speaker or communicator is referred to as Idea I. The idea, mind of receiver, listener, or interpreter is classified as Idea C. The basic problem of the speaker to get the idea into the mind of the listener in such a way that Idea C will correspond exactly to Idea I that is, the message will have the same meaning to both. When these two ideas correspond, there is an agreement in the communication process. If they do not correspond, there is distortion. This can be illustrated in a cyclic form as follows:



From the diagram we can see that communication is too complex to be viewed simply as a process of sending and receiving message. The speaker has a meaning, he has to choose a medium, and then he has to frame a message. The sender has an idea or an intention which he has to encode into a message. One has to choose the medium. Encoding immediately presents a block or a barrier of Idea I to be equal to Idea C.

Elements of Communication

1. Source
2. Message
3. Channel/media
4. Receiver
5. Feedback

Media is, through which a message/idea is transmitted and then that is received by the receiver to decode the as the same message and the receiver expresses his/her reaction which is called feedback.

Barriers of Communication

Communication is the process of imparting, transmitting or sharing information of one kind or another. But this process is not always smooth. We do not always succeed in transmitting the

intended message to the other party because of the existence of various barriers of communication. We become surprised at the non-response or unexpected type of response of the other party. Sometimes, this is because we lack knowledge about ourselves, and at other times, because we know so little about other people. Following may be specified as barriers to communication.

1. The speaker and listener may differ in education, experience and background.
2. One may fail to convey the information the listener needs and can understand.
3. One's stereotypes and beliefs influence what one hears.
4. One's emotional state of mind colours what one hears.
5. Individual conflict.
6. Suspicion about the speakers motivation.
7. Imperfect listening.
8. Failure to evaluate the meaning behind what we hear.

Steps To Improve Communication

1. Plan your communication.
2. Projection.
3. Timing.
4. Believability.
5. Simplicity.
6. Repetition.

Effective Communication

Communication is a very important part of the educational process. While learning aims at changing in level of knowledge, change in attitude and change in behaviour it is implied that the impact of communication also lies in the change that has been effected in the knowledge, attitude and behaviour. Needless to say, communication can be considered effective only if the ideas or the message have been properly received, interpreted and utilised for enhancement of knowledge or change of attitude and behaviour. From the experiences gained from social psychology, there is a close link between knowledge, attitude and behaviour and it is generally believed that the knowledge (information) precedes change of attitude which in turn precedes change of behaviour. So also communication has to step up the knowledge first and this knowledge gained is supposed to motivate further and bring about a change in attitude and behaviour. In any case it is expected that communication will serve its purpose only if the change in knowledge level has been achieved.

Effective communication therefore means to begin with a communication that has not only reached the receiver but has enabled the receiver to have a change in the level of knowledge. For effective communication to take place, the following points are essential.

Communicator:

The communicator should possess the following characteristics.

1. S/he should be knowledgeable and fully conversant with the subject under discussion.
2. S/he should have credibility before the receiver which he gains by his sincerity, honesty and intellectual capability.
3. S/he should have proper attitude towards the receiver and subject matter.
4. S/he should have proper communication skill in selecting and using the channel.
5. Feedback should be ensured.

Message:

The message content should be brief and clear.

1. It should be need-based and timely and appropriate and relevant.
2. It should be supported by factual material to give it proper authenticity.
3. The channel should be manageable by the communicator and should be appropriate.

4. Treatment of the message is also important. Its purpose is to make the message clear, understandable and realistic and specially situated for the channel or media that has been selected. Some of the salient principles in treatment of message for effective communication are as follows:

- Proper emphasis where required.
- Repetition for the sake of emphasis.
- Contrast of ideas and comparisons.
- Logical sequence.
- Redundancy for reduction of noise.

Channel or Media:

1. It should be familiar both to the communicator and the receiver.
2. It should be appropriate to the message.
3. It should be available and accessible.

Receiver:

1. Like the communicator, the receiver also should have proper attitude and the desire to receive the communication.
2. The receiver's sensory organs should be intact and in good working condition.

Factors to be considered for effective communication:

1. Language:

Language is the oldest means of interpersonal communication. The sender of the message must communicate through language which must be understandable to the receiver. If the receiver can not understand the language, accent, meaning etc. the whole purpose of communication shall be defeated. Therefore, in order to communicate effectively, the sender must communicate with the receiver with the common language.

2. Ideas:

No two individuals are identical due to their differing attitude, perception; ideas etc. Man is the product of the environment. His/her personality, perception and attitude develops as he became socialized with his/her environment in which he/she grows up. Therefore, while communicating, one should take care of this human individual uniqueness.

3. Experience:

Acceptability of any message to a receiver shall be higher if it matches with the knowledge and experience. Therefore, the sender should transmit his message in a way that conforms to ones belief and experience.

4. Values:

Values is one of the important factors to be considered in course of communication. That is why if we want to send any message or inculcate any idea, we must consider the values, belief etc. of the target group.

5. Hopes and aspirations:

Man wants to live long in good health, peace and prosperity. To achieve this, every human being wants to spend time and resources. If the communication is made in a way to the target group that will fulfil their inherent needs and desires, the message will be readily acceptable.

Means of communication

1. House visit
2. Letter
3. Telephone

4. Meeting
5. Demonstration
6. Role play
7. Slide
8. Newspaper
9. Radio/Television
10. Poster, Bill board

Qualities of a good communicator

A good communicators should possess the following qualities based on:

i. knowledge
ii. attitude
ii. skill.

i. Knowledge based:

- Knowledge about the communication process and techniques
- Knowledge about how to motivate target group
- Knowledge about implementation of development programmes
- Knowledge about environment
- Knowledge about socio-economic condition of the locality.

ii. Attitude based

- Friendliness
- Sense of responsibility
- Respect for social values
- Mentality to gain confidence of the target group
- Sympathetic
- Willingness to solve problems from the point of view of target population.
- Respectful to human abilities.

iii. Skill based:

- Ability to deliver lecture
- Ability to demonstrate communication aids/materials
- Analytical ability
- Ability to run the meeting
- Skill in developing materials.

Communication of WSS Message

- Carefully go through the WSS issues;
- Develop the message for solving WSS problems;
- Prepare for communication of the message;
- Organise meetings, visit the communities and talk;
- Help to remove discrepancies among male and females.

You will agree that if you follow the communication knowledge, the message on gender issues can easily be sent to all. Thus, we can create gender awareness among both males and females which will ultimately help to make gender balance.

06 Health Promotion & Hygiene Education

In our country about 44% of the rural population uses sanitary latrines. People are now conscious of using latrine and 61% of the total population are using some form of latrine. Overall urban sanitation coverage has risen from 20% to 42% since 1981. The commonly used options in rural sanitation are the 'home-made' and single pit latrines. Of the sanitary latrines in the rural areas, 60% are home made. In urban areas water borne sewerage system and a range of on-site options such as septic tanks, single and double pit latrines are used. Only Dhaka city has a limited sewerage system that covers only 18% of the population.

People in general has very poor understanding about the relationship between health and sanitation. Rural sanitation suffers much from poor understanding of the health benefits of sanitary latrines. Latrines are used for reasons of convenience and privacy rather than health reasons. In slum areas, situation is deplorable. The sanitary condition of slums are miserable and inhuman. Most of the slum dwellers have literally no latrines, only a few have pit or surface latrines. They often defecate in open fields, in the bushes, near the roads, in the drains or on the riversides. The problem is acute with female residents who have to wait till sunset for defecation or use a neighbours latrine, if available

1.0 Introduction

It is always easier to change technology than to change people's behaviour and practices. With this thought in mind any project related to water supply and sanitation should be designed giving more emphasis on hygiene education program and its relation with new technology.

It is necessary to encourage the community to actively participate in the planning and execution of the project and also take part in hygiene education.

Water-borne diseases which are widespread in a rural areas are transmitted directly through contaminated drinking water. It can be controlled and eliminated by installing and using a safe, potable water supply. Through experience it became evident that, appropriate technology is not enough to improve health, because it is more difficult to change people's hygiene behaviour. Therefore, it is essential to understand the people's perception of disease and design hygiene messages accordingly.

2.0 Community Leaders

Community leaders normally provide the encouragement and guidance for their communities to participate in a water supply and sanitation project and its hygiene education component. Before they will co-operate, these leaders must believe that the project will benefit their people and not conflict with their own interests.

The project personnel must identify the leaders and meet with them. Leaders are generally of two types; formal and informal. The formal leader is someone with a title who has been officially chosen for a position. Such leaders may be found in :

- traditional hierarchy
- local government
- religious or cultural organisations
- trade associations
- craft unions
- self-help societies
- social clubs
- educational institutions.

A second important category is the informal leader. These leaders have no special title and appear at first glance to be ordinary citizens. But the opinions, requests and suggestions of these people are well respected by the community. The quality of informal leaders comes from their personal qualities and abilities. Examples of informal leaders may be :

- the midwife who has years of experience delivering babies and raising children. She is directly involved in hygiene practices, and often prescribes curative and preventive remedies for illness. She also has the confidence of women in the community.
- A primary health worker or volunteer who has been selected by her community;
- a successful farmer or businessman;
- a successful market-woman or storekeeper;
- the oldest person in the community with a wealth of knowledge about the history and customs of the people, including those related to water and hygiene;
- the school teacher who may eventually be a valuable resource in teaching hygiene to the children.

3.0 Planning for Hygiene Education

The promotion of hygiene education will require a specific body in the community through which planning and action can be co-ordinated. The community's water supply and sanitation committee may be able to do this work. Or, an existing group in the community, which is involved in development work, may be the likely candidate for planning hygiene education.

If there is no appropriate existing group, a committee can be formed drawing on people from representative groups and interests in the community, such as farmers' unions or market associations. In communities which do not have any organisations like these, a completely new group might have to be formed. For the long-term benefit of the community, this new organisation should have the broad goal of community development, with water supply, sanitation and hygiene education as its first priority. It should be representative of the different ethnic, economic, religious and political sectors of the community.

Any committee formed to plan for hygiene education should involve women. Hygiene education is one of the principal roles of women within the household. It is essential that women, as individuals and in groups, be involved as early and as fully as possible, if the expected changes in behaviour are to occur.

3.1 Involving Outside Agencies

Although one agency will be in charge of the water supply and sanitation project, other outside agencies may provide useful assistance in hygiene education. For instance, a public health centre may be able to teach mothers the proper way to dispose of their children's excreta. An agricultural extension agency could explain to men the health risks of defecating in open fields. All such agencies may be utilised. The community organisation responsible for the project may wish to invite representatives of these agencies to share ideas on hygiene education methods and assistance.

3.2 Implementing Hygiene Education

The project personnel should take care not to impose new models or organisations on existing structures in the community. In the case of hygiene education the community efforts toward primary health care through local committees and volunteer workers must not be ignored. Even though it may not be an ideal solution, the decision about whether to organise a new group, and what rules, activities and structures it should adopt, should be left primarily to the community.

3.3 Community Awareness, Needs and Practices

A survey of the community helps project staff to understand community needs, behaviours, beliefs, attitudes, values and resources. At the same time, community members can begin to understand the alternative technologies available and how they relate to their needs. With this

information the hygiene education team, which may includes the project personnel, government representatives and other technical professionals, can develop a program with the community.

3.4 Paying Attention to Community Beliefs

Project staff should play close attention to the habits, beliefs and taboos of the target population. This type of information, particularly when collected from the women, can provide a starting point for hygiene education messages to change the way people use water and dispose of excreta.

3.5 Staff Training

Subjects to train workers in hygiene promotion may include:

- communication and human relations skills;
- skills in making and using simple educational aids (stories, songs, posters, banners, role playing etc.), using local materials and people;
- knowledge of the correct and healthy ways for people to use the new facilities;
- knowledge of the effects on health of water use and sanitation practices;
- understanding of how local beliefs, values, customs and attitudes may affect water use and sanitation practices.

4.0 Who Should Get The Message

4.1 Reaching Women

Women have a special role in hygiene education and they need to be involved in the early stages of the program. The information and training planned for women should be closely related to the school's hygiene curriculum.

Low-cost teaching aids prepared for classroom instruction can be used in the special training programs for clinics and groups of women. The teaching techniques must be planned with the users in mind, and so must the location and time for these educational activities.

4.2 Reaching Parents through Health Centres

Maternal child health clinics and midwives should receive messages similar to those given to women. These types of clinics should be the first places in a community to have access to improved water supply and sanitation facilities.

4.3 Reaching Children in the Schools

The hygiene curriculum should be in use while the project works in the community. In this way students will be knowledgeable about the new facilities and can practice their new hygiene skills as soon as the project is completed.

The curriculum committee should consider how to make low-cost teaching aids from locally available materials. Models of clay and wood, hand-drawn posters and stories are examples. Workshops can be held to show people how to produce these materials.

4.4 Children

Children form a large group of water users and in some communities they do much of the labour involved in fetching water and disposing of refuse. The children can be taught at school to use water supply and sanitation facilities to improve their health. They can also help their mothers change the hygiene behaviour of their brothers and sisters. However, the mothers must also understand and appreciate good hygiene practices.

4.5 Reaching Parents Through the Schools

Parents may not listen to what their children tell them they have been taught in school. An active effort by the schools to reach the parents can help children introduce new ideas learned at school to their family. Some of the following activities may help educate and involve parents.

- Presentation at meetings by parents and teachers;
- efforts to get contribution (money, materials, technical advice and labour) to help provide water supply and sanitation facilities for the school;
- plays by the children about water, sanitation and hygiene practices presented to the parents;

4.6 How to Get The Message Across

Achieving the educational goals usually involves using various types of mass media and 'large group' educational techniques. These must be reinforced by personal contact and locally relevant materials to be effective. The best results will be achieved by a mixture of communication methods that combines a presentation of information with instructions and demonstrations of how parasites spread, how to use the new sanitation facilities, etc.

Some of the communication methods may require electricity, literacy, or large audiences and may be more be more feasible in urban settings. For rural areas, traditional plays, story-telling or festivals can be made part of the educational process.

Review of Hygiene Education

Here are some of the main points about hygiene education that have been discussed in these notes:

- Hygiene education must be a multi-disciplinary effort by the planning team, the implementing team and the community.
- The community must be involved in planning the hygiene education program.
- Hygiene education is a long-term activity- health improvements and changes in hygiene practices can take yeas to achieve.
- Good health and good hygiene are made possible by a combination of education, improvement in personal hygiene and appropriate water and sanitation technologies.
- Community needs and community development objectives can be related to better health and improved hygiene.
- Background information on a community is needed before planning can begin for the hygiene education program. Project staff should be aware of local leadership, local customs and which outside agencies and local institutions can assist in hygiene education.
- A detailed community survey must be carried out to determine local hygiene conditions, needs, perceptions of health and hygiene, local attitudes towards water use, defecation and choice of new facilities, and local resources for education.
- Project staff should identify community self-help organisations which can help promote hygiene education.
- Hygiene messages must be designed for their specific audience, particularly women and children.
- Hygiene messages can be passed on using many techniques- from hand drawn posters to short radio broadcasts.

07 Water Quality Problems: Arsenic, Iron & Microbial Quality

ARSENIC PROBLEM

Arsenic and arsenical compounds are extremely toxic. Yet they are found in effluents and leaches from metallurgic industries, glassware and ceramic industries, dye and pesticide and fertiliser manufacturing industries, petroleum refining, rare earth industries and other chemical industries. In some parts of the world arsenic occurs naturally scattered in the soil, from where it leaches to the groundwater.

In recent years the spot wise occurrence of arsenic in the groundwater is increasingly acknowledged as a major health problem for the respective communities. Partly because of improved possibilities for monitoring the water quality, partly because of increasing utilisation of groundwater resources, the arsenic problem seems to be augmenting in many developing countries, e.g., China, Taiwan, India, Ghana, Chile and Bangladesh. Many West Bengali and Bangladeshi communities are considered to be at high arsenic risk. According to Mandal et al. (1997) about 34 millions people are "at risk" due to arsenic in drinking water in West Bengal. Similarly according to Dave (1997) about 23 million people are "at risk" in Bangladesh.

The precise dimension of the arsenic problems are yet to be measured in Bangladesh. This is not an easy task. Arsenic in water is tasteless, odourless and colourless. Furthermore its analyses are relatively complicated and not well established and its effects on the population are often delayed, diffuse and difficult to detect. However, there is no doubt that the arsenic problem is serious and has been hidden and/or ignored in many areas for too many years.

It has to be added, that the panic over-reaction to the arsenic problem may be more harmful to communities than the arsenic itself. Many communities, who have been educated to use the microbiologically safe groundwater may, without proper sizing of their arsenic problem, change their habits back to the use of the surface water, which most often is contaminated with pathogenic micro-organisms. It has to be borne in mind that the health significance of water related infectious diseases is much higher than that of arsenic, even among the above mentioned communities at high arsenic risk.

Arsenic Chemistry

Arsenic occurs in water in several different forms, depending upon the pH and the redox potential, E_h. Some of the most important compounds and species are shown in Table 1.

Table 1 Arsenic compounds and species and their environmental and toxicological importance in water. Data from: Stueart et al. 1996, Kartinen & Martin 1995, WHO 1996,

Compounds	*Example*	*Aquat. Environment*	*Toxicity*
Arsine	As^{3-}	Minor importance	Most toxic As species
Elemental arsenic	As	Minor importance	Least toxic As species
Trivalent arsenic	As(III)	Anaerobic	10 x more than As(V)
Arsenite, Inorganic	H_3AsO_3,	pH = 0-9	
	$H_2AsO_3^{1-}$,	pH = 10-12	
	$HasO_3^{2-}$,	pH = 13	
	AsO_3^{3-}	pH = 14	
MMAs(III)	$CH_3As(III)O_2^{2-}$	Several fungi & bacteria	Less than inorganic
DMAs(III)	$(CH_3)_2As(III)O^{1-}$	can methylate As(III)	As(III)

Compounds	*Example*	*Aquat. Environment*	*Toxicity*
TMAs(III)	$(CH_3)_3As(III)$		
Organo-As(III)		Minor importance	
Pentavalent arsenic	As(V)	Aerobic	10 x less than As(III)
Arsenate,	H_3AsO_4,	pH = 0-2	
Inorganic	$H_2AsO_4^{1-}$,	pH = 3-6	
	$HasO_4^{2-}$,	pH = 7-11	
	AsO_4^{3-}	pH = 12-14	
MMAs(V)	$CH_3As(V)O_3^{2-}$	Methylation through	Less than inorganic
DMAs(V)	$(CH_3)_2As(V)O_2^{1-}$	reduction of As(V) to	As(V)
TMAs(V)	$(CH_3)_3As(V)O$	As(III)	
Organo-As(V)		Minor importance	

Because the solubility of arsine and elemental arsenic is extremely low, these species may occur in the underground, which most often has a low redox potential, without appearing in the groundwater. Both arsenic (III) and (V) are more soluble. But as the redox potential is never high in the underground, As(III) would be the most dominant arsenic species in contaminated aquifers.

The arsenious (arsonic) and arsenic (arsinic) acids are dissociated according to the equations:

Arsenious Acid Dissociation:						
	H_3AsO_3	=	H^+	+ $H_2AsO_3^-$	pKa = 9.22	eq. 1
	$H_2AsO_3^-$	=	H^+	+ $HAsO_3^{2-}$	pKa = 12.3	eq. 2
Arsenic Acid Dissociation:						
	H_3AsO_4	=	H^+	+ $H_2AsO_4^-$	pKa = 2.2	eq. 3
	$H_2AsO_4^-$	=	H^+	+ $HAsO_4^{2-}$	pKa = 7.08	eq. 4
	$HAsO_4^{2-}$	=	H^+	+ AsO_4^{3-}	pKa = 11.5	eq. 5

Thus within the range of natural waters, where pH most often is between 6 and 9, trivalent inorganic arsenic is found primarily as non-dissociated arsenious acid, while the pentavalent arsenic is primarily found as ionised di-hydrogen arsenate and mono-hydrogen arsenate. As most treatment processes are most capable to remove ions, the trivalent arsenic is more difficult to remove from the water than the pentavalent (Kartinen & Martin 1995).

Arsenic Toxicology

Arsenic is 20th most abundant element in the earth's crust and the 12th most abundant element in the biosphere, where it is said to be an essential element at least for some animal species, but not for human (Kartinen et al. 1995, WHO 1996). Table 2 indicates the approximate environmental concentration levels and human exposure through the air food and water.

Table 2. Approximate environmental concentration levels and human exposure through air, food and water. Data from WHO 1996.

Medium	*Concentration*	*Daily intake*	*D. Exposure*	*Remarks*
Air	0.4-30 ng/m^3	20 m^3	0.01-0.6 µg	May be much higher in industrial areas
Food	0.4-120 µg/kg	1 kg	0.4-120 µg	75 % is organic As 25 % is inorganic As
Water, generally	2 µg/L	2 L	2-4 µg	Mainly inorganic As(III), most toxic
Water, up to	12000 µ/L	2 L	24000 µg	

Ingested elemental arsenic is not soluble and therefore poorly absorbed from the gastro-intestinal tract. As(V) and organic As are rapidly and almost completely eliminated via the kidney. Contrary to these, the soluble arsenic compounds are rapidly absorbed. Inorganic As has a tendency to accumulate in skin, bone, nails, hair and muscles. Its half life in human is estimated to be between 2 and 40 days. Arsenic(III) in its non-methylated form is eliminated from the body by rapid urinary excretion. Furthermore Arsenic(III) is in part detoxificated in the liver to monomethylarsenious acid and dimethylarsenic acid.

Arsenic is not mutagenic in bacterial and mammalian assays. But it is proven to be carcinogenic for both humans and animals. It is known to be teratogenic and to induce chromosome breakage and sister chromatid exchange in a variety of biological cells.

Table 3 Toxicological effects of arsenic reported due to exposure to high arsenic concentrations in the drinking water. WHO 1995. Wadud Khan 1997.

Effect	*Symptoms*	*Remarks*
Blackfoot Disease Arsenical dermatosis	Dermal lesion, Peripheral neuropathy Keratosis, Hyperkeratosis, Hyperpigmentaion	May necessitate operation
None specific	Nausea, Abdominal Pain, Diarrhoea, Vomiting, Conjunctivitis, Oedema.	Mainly due to acute intoxication
Pregnancy disorders	Spontaneous abortions, miscarriages	-
Heart Disease	Coarctation of aorta, Cardiovascular disturb.	Among children
Cancer	Bladder, Kidney, Skin & Lungs, Liver & Colon	-
Mortality	-	Mainly due to cancer

In a population drinking arsenic contaminated water, a great variety of specific as well as non-specific symptoms may be observed at a large biological variations and interactions (Mazumder et al. 1997). Table 3 shows some of the effects of arsenic reported to be due to exposure through drinking water. There is still no well established guidelines about how to measure quantitatively the severity of arsenosis in a population. Thus the correlation between the severity of the disease and the contamination levels of the consumed water are yet to be established. Also a convincing correlation between the concentration of arsenic in the drinking water and the concentrations of arsenic in the urine, hair and nails are yet to be established (Mazumder et al. 1997).

Guidelines for Arsenic

The Tolerable Daily Intake, TDI, is an estimate of the amount of substance per kg of body weight that can be ingested daily over a life time without appreciable health risk. For a proven human carcinogen chemical like arsenic it is generally accepted that the threshold values, TDI, do no exist. This is because, theoretically, there will always be a probability of harmful effect, i. e., risk, at any level of exposure (Galal-Gorchev 1997).

Estimated risks are normally based on 60 kg person, drinking 2 L of water per day, for a life time of 70 years. The WHO guideline value for substances in drinking water is the concentration corresponding to an upper-bound estimate of an excess lifetime cancer risk of 10^{-5}. In other words *GV* is the concentration expected to give one additional cancer case per 100,000 people ingesting the water for 70 years.

On this basis the arsenic concentration for acceptable skin cancer risk is calculated to be 0.17 µg/L. For practical limitation in available analysis methods, cf. Table 4, only a ***provisional*** guideline value of $GV=10\mu g/L$ is established. Thus the estimated excess lifetime skin cancer

risk associated with exposure to 10μg/L drinking water concentration for a lifetime of 70 years is: $P = (10\ \mu g/L \cdot 10^{-5}) / 0.17\ \mu g/L = 6 \cdot 10^{-4}$;
i.e. 6 additional skin cancer cases per 10 000 exposed.
For comparison, the national standards adopted are 10 μg/L in the European Union, 25 μg/L in Canada and 50 μg/L in the US EPA (Galal-Gorchev 1997).

From Table 4 it may be concluded that monitoring and surveillance of the water resources, especially in rural areas of developing countries is a huge task to deal with. Figure 6 shows one of the available field kits (the Indian type). Several others are available. Even these field kits would need some kind of lab training.

Table 4 Simplified overview of analysis methods for testing arsenic.

Methods	*Advantages*	*Disadvantages*
1 Flow Injection-Hydride Generation-Atomic Absorption Spectrometry		
	Most sensitive, down to 1-4 μg/L.	Very high cost of investment.
	Least interference.	Very high cost of O & M.
	Most reproducible.	Dependency of foreign company specific spare parts.
		Dependency on imported chemicals.
		Dependency on expert technicians.
2 Hydride Generation-Scraper-Spectrophotometry		
	Medium sensitivity, e. g. 10-30 μg/L.	High cost of investment.
	Medium reproducibility.	High cost of O & M.
	Normally low interference.	Dependency on imported chemicals.
	Relatively low cost of investment, apart from spectrophotometer.	Dependency on trained technicians.
3 Hydride Generation-Scraper-Indicator Paper-Field Kit		
	Relatively easy to use to field.	Quantitative indication of occurrence
	Low investment costs.	Low sensitivity.
	Low chemical costs.	Low reproducibility.
	Easy to train on use.	Risk of false negative response.
		High interference (solar irradiation)
		Dependency on imported chemicals.
		Dependency on trained technicians.
		Not yet tested and standardised.

Arsenic Removal

Overview
Experiences on dearsination of water are extremely limited, especially when it comes to implementation in rural areas of developing countries, where the problems are at most.
The methods available today are based on old well known techniques supplemented with oxidation of As(III) to As(V) as a pre-treatment in order to increase the removal efficiency.
Broadly the methods can be categorised in three groups:

- The coagulation / co-precipitation techniques.
- The sorption techniques.
- The membrane techniques.

Alum Coagulation

In the alum coagulation process aluminium sulfate, $Al_2(SO_4)_3$, $18H_2O$, is dissolved and added to the water under efficient stirring for one to few minutes. Rapidly the aluminium hydroxide micro-flocs are produced and gathered into larger easily settling flocs. Hereafter the mixture is allowed to settle. During this flocculation process all kinds of micro-particles and negatively charged ions are removed by chemical and electrostatic attachment to the flocs, eq. 8 -11.

The treated water can be decanted. Safety filtration is however required in order to ensure that no sludge particles are escaping with the water.

As the trivalent arsenic occurs in non-ionised form it will not be subject to significant removal. Oxidation of As(III) to As(V) is thus required as a pre-treatment. This can be achieved by addition of any chlorine product or by addition of permanganate, eq. 6 & 7. The chemical equations may be shown as follows:

As oxidation with Cl_2:	
$H_3AsO_3 + HClO = HAsO_4^{2+} + Cl^{1-} + 3H^+$	eq. 6
As oxidation with permanganate:	
$3H_3AsO_3 + 2\,KMnO_4 = 3HAsO_4^{2+} + 2\,MnO_2 + 2K^+ + 4H^+ + H_2O$	eq. 7
Alum dissolution:	
$Al_2(SO_4)_3, 18H_2O = 2Al^{3+} + 3SO_4^{2-} + 18H_2O$	eq. 8
Aluminium precipitation (Acidic):	
$2Al^{3+} + 6\,H_2O = 2Al(OH)_3 + 12\,H^+$	eq. 9
Co-precipitation (None stoichiometric, not defined product):	
$H_2AsO_4^- \; Al(OH)_3 = Al\text{-}As\ complex + ?$	eq. 10
pH adjustment:	
$6Ca(OH)_2 + 12\,H^+ = 6\,Ca^{2+} + 12H_2O$	eq. 11

The alum dearsination is thus based on pre-oxidation + conventional flocculation techniques. It has been tested as well at household level as at village handpump level. For initial As concentrations of 300 µg/L and dosage of about 30 mg Alum/L removal efficiencies about 90 % can be achieved, provided pH is not higher than 7 and not lower than 6 (Katrinen & Martin 1995). See also table 10.5.

Iron Coagulation

The iron dearsination resembles the alum method. In stead of Alum, ferric sulfate $Fe_2(SO_4)_3$ or ferric chloride $FeCl_3$ are added. In general 30 mg/L are comparable to 100 mg/L alum. For initial As concentrations of 300 µg/L and dosage of about 30 mg ferric sulfate/L removal efficiencies about 95 % can be achieved, provided pH is not higher than 8.5 and not lower than 6 (Katrinen & Martin 1995). See also table 5.

In Bangladesh, arsenic has been found with dissolved iron in variable concentrations. Hand tubewell water in about 65% of the area of Bangladesh contains dissolved iron in excess of 2mg/L and in many areas, the concentration of dissolved iron is around 15 mg/L. It has been found that, in general, there is a positive correlation between the presence of arsenic and iron in groundwater and higher concentration of arsenic in groundwater has been found in acute iron problem areas. Naturally occurring iron in groundwater readily forms iron (ferric hydroxide) precipitates upon extraction in the presence of atmospheric oxygen. This naturally occurring iron may, therefore, play an important role in removing arsenic from groundwater. This approach can simultaneously remove arsenic and iron-two major water quality constraints the development of groundwater based water supply system in Bangladesh.

Table 5 Removal of As(V) achieved at laboratory conditions for given initial pH and dosage of alum and ferric sulphate. Both coagulations were followed by sedimentation and sand filtration. Data from Gulledge & C'onnor1973.

Dosage mg/L	*Removal by alum coagulation %*				*Removal by ferric sulfate coagualtion %*			
pH:	*5.0*	*6.0*	*7.0*	*8.0*	*5.0*	*6.0*	*7.0*	*8.0*
10	59	75	65	19	97	97	94	89
20	82	89	82	39	97	98	97	90
30	91	91	84	47	96	98	97	97
40	93	89	91	67	95	99	99	96
50	92	94	91	66	99	98	98	97

Lime Softening

Lime softening implies addition of fresh calcined lime, calcium oxide, CaO. The precipitated calcium hydroxide acts as sorbing flocculant for arsenic. Excess of lime would not be dissolved, but remains as a thickener and coagulant aid, which has to be removed along with the precipitated calcium hydroxide through a sedimentation/filtration process. Experiences have shown that the arsenic removal is relatively low, between 40 and 70 %. The highest removals are achieved when the end pH of the water is as high as 10.6 to 11.4. Obviously this would require a secondary treatment in order to readjust the pH. Simple acidification may no be enough, buffering of the water may ultimately be required. The lime softening can be used as a pre-treatment to be followed by e. g. iron coagulation.

Activated Alumina

Activated alumina is aluminium oxide, Al_2O_3, grains prepared in a way that grains have sorptive surface. When the water passes through a packed column of activated alumina, pollutants and other components in the water are adsorbed to the surface of the grains. Eventually the column becomes saturated, first at its upstream zone. Later, as more water is passed through, the saturated zone moves downstreams and in the end the column get totally saturated. The total saturation means that the concentration of the pollutant under consideration in the effluent water increases to the same value as the influent water. The different pollutants and components of the water get saturated at different times of operation, depending upon the specific sorption affinity of medium to the given component.

The total saturation of the column must be avoided. The column is only operated to a certain break point, where the effluent concentration is e.g., 50 µg/L. The time between the start of operation and the break point of the column is presented by the volume of treated water V. When dividing V with the bulk volume of the activated alumina packed, a standard parameter is obtained; i.e., the number of Empty Bed Volumes, EBV, or just Bed Volumes, BV. BV is an expression of the capacity of treatment before the column medium needs to be regenerated. It is an operational measurement of the specific sorption capacity of the given activated alumina towards arsenic.

Regeneration of the saturated alumina is carried out by exposing the medium to 4 % caustic soda, NaOH, either in batch or by flow through the column, resulting in a few BV of caustic high arsenic contaminated wastewater. Residual caustic soda is then washed out and the medium is neutralised with a 2 % solution of sulfuric acid rinse. During this process about 5-10 % alumina are lost, and the capacity of residual medium is significantly reduced, 30-40 %. After only 3-4 regenerations the media has to be replaced. Alternatively, in order to avoid on site regeneration, the saturated alumina can be recycled to a dealer, who can take care of

standardising the capacity of the activated alumina using an appropriate mixture of fresh and regenerated media.

As with the coagulation processes, the pentavalent arsenic is removed far more efficiently than the trivalent arsenic. Hence the use of pre-chlorination improves the column capacity dramatically. It has been reported that 23000 BV of pre-chlorinated synthetically contaminated water at a level of 100 µg As/L could be treated to a break point of 50 µg/L. Without pre-chlorination of the water, only 300 BV could be treated. Similarly, 16000 BV of pre-chlorinated water could be treated, compared to 700 BV for non-chlorinated water. The optimum pH is found to be 6. Deviation from this pH is found to reduce the capacity of the activated alumina dramatically, (Kartinen & Martin (1995).

Ion Exchange

Ion exchange is normally used to demineralise, to soften and de-nitrate the water. The process is similar to that of activated alumina, just the medium is a synthetic resin of more well defined ion exchange capacity. As the resin become exhausted, it needs to be regenerated. The principal regenerated agent is chloride, i.e. a salt solution:

Arsenic exchange (R = Resin):

$$2R\text{-}Cl + HAsO_4^{2-} = R_2HAsO_4 + Cl^{2-} \quad \text{eq. 12}$$

Regeneration:

$$R_2HAsO_4 + 2\,Na^+ + 2Cl^- = 2R\text{-}Cl + HAsO_4^{2-} + 2\,Na^+ \quad \text{eq. 13}$$

Capacities of 4000 BV has been reported (Stueart et al. 1996). The arsenic brine is produced from about 2 BV of 1 N NaCl. The removal capacity is however much dependent on the contents of sulfate in the raw water, as sulfate is ion exchanged before arsenic. One minor advantage of the ion exchange process is that the performance is less dependent on pH.

The efficiency of the ion exchange process is also radically improved by pre-oxidation of As(II) to As(V). This, however, has the drawback that the excess of oxidant has to be removed before the ion exchange in order to avoid the damage of the resin.

Other Sorption Media

Several other sorption media has been reported to remove arsenic from water, e.g., activated carbon, kaolinite clay, hydrated ferric oxide, activated bauxite, aluminium oxide, titanium oxide and sand (silicium oxide). The results demonstrate much discrepancies, probably due to great variation in the tested media and the experimental conditions. It must be mentioned that indications of the removal efficiencies obtained under laboratory conditions, as most often found in literature, can be most misleading as a criteria for evaluation of the sorption methods (Stueart et al. 1996).

Comparative studies, where the removal capacities are obtained for natural water containing "normal" contamination levels are yet to be carried out.

Membrane Techniques

Reverse osmosis and electrodialysis are capable of removing all kinds of dissolved solids from the water, thus resulting in demineralised water not suitable for drinking, unless reconditioned.
It is a precondition that the water does not contain suspended solid and that arsenic is in its pentavalent state. Most membranes however, can not withstand oxidising agents. Moreover,

these methods are already of no interest in developing countries, because of their nature as high tech and high cost.

Table 4 Overview of dearsination methods and their advantages and disadvantages. Membrane methods are considered as none appropriate.

Method	*Advantages*	*Disadvantages*
Coprecipitation:	No monitoring of a break through is required. Relatively low cost simple chemicals. Low capital costs.	Serious short and long term problems with toxic sludge. Multiple chemicals requirement. Operation requires training and discipline.
Alum coagulation	Durable powder chemicals normally available.	Efficient pre-oxidation is a must.
Iron coagulation	More efficient than alum on weigh basis.	Medium removal of As(III).
Lime softening	Most common chemicals	Re-adjustment of pH is required.
Sorption techniques:	No daily sludge problem.	Requires monitoring of break through or filter use. Requires periodical regeneration or medium shift.
Activated alumina	Relatively well known and commercially available.	Re-adjustment of pH is required.
Iron coated sand	Expected to be cheap. No regeneration is required.	Yet to be standardised. Toxic solid waste.
Ion exchange resin	Well defined medium and hence capacity.	High cost medium. High tech operation & maintenance. Regeneration creates a sludge problem.
Other Sorbents	Plenty of possibilities & combinations	Not yet properly studied.
Membrane techniques:	Well defined performance. High removal efficiency. No solid waste. Low space requirement. Capable of removal of other contaminants, if any.	High running costs. High investment costs. High tech operation and maintenance. Toxic wastewater. Re-adjustment of water quality is required.
Reverse osmosis		Membrane does not withstand oxidising agents.
Electrodialysis		Membrane does not withstand oxidising agents.

Avoidance

In the West Bengal-Bangladesh arsenic contaminated belt, ground water occurs in both confined and unconfined aquifers. The aquifers are recharged mainly through rainwater infiltration and seepage of irrigation water. Broadly the aquifers are classified in three groups:

- The shallow aquifers; less than 50 m bgl.
- The intermediate aquifers; between 50 and 150 m bgl.
- The deep aquifers; more than 150 m bgl.

The experiences gained in West Bengal shows, in general, that the arsenic is detected is the shallow and intermediate aquifers. As a rule, the arsenic contents decreases with increasing depth. Excessive withdrawal of groundwater during summer when the recharge is low, and the seasonal groundwater drawdown, is speculated to facilitate exposure of underground formations, which may contain arsenic immobilised as arsenopyrite, to atmospheric oxygen. Such an oxidation would lead to mobilisation of the underground arsenic to the ground water.
According to this theory, the large scale irrigation from shallow tube wells may in the long run extracts large amounts of geologically fixed underground arsenic, bringing it up to the surface, and subsurface, to the shallow and intermediate aquifers and hence to the biosphere, (Acharya 1997).

At a village level, however, the occurrence of arsenic is highly scattered, even when the wells are draining the same shallow aquifer. Thus much can be achieved though proper monitoring, even at decentralised level, for the avoidance of arsenic contaminated water.

From Table 4 it may be seen that the dearsination methods, though available, do have severe disadvantages. Probably much have to be investigated, before more appropriate methods can be developed. Avoidance of the arsenic sources, is therefore the methods of choice, as far microbiologically safe alternative sources can be provided.

IRON PROBLEM IN GROUND WATER OF BANGLADESH

Water is a basic necessity of man along with food and air, the importance of Supplying hygienic potable/fresh water can hardly be over stressed. The impact of many diseases afflicting mankind can be drastically reduced if fresh hygienic water is provided for drinking. Bangladesh is heavily dependent on ground water for drinking water supplies. Ground water quality of any area is of great important for human being. The ground waters irrespective of their source of origin contain mineral salts and other chemical compounds such as iron, manganese, nitrate, fluoride, chloride, calcium, sodium etc. The kind and concentration of constituents depend upon various geological, geo-hydrological and physical factors of the aquifers. The quality and composition of the dissolved mineral in natural water depend upon the type of rock or soil with which it has been in contact or through which it has percolated, and the duration it has been in contact with these rocks. The quality of ground water may very from place to place and stratum to stratum. It also varies from season to season. Iron occurs in underground water as a soluble (ferrous) from and it becomes as an insoluble (ferric) from when it comes in contact with air. Presence of iron in water changes the characteristics of fresh water, alters colour of water as well as taste of water. Water with high iron content makes the teeth and nail black and weak, stickiness of hair and roughness of skin. Soap also don't response well if iron is present in water. Iron problem is acute in various places in groundwater of Bangladesh. The following section describes the result of an investigation that was carried out to study the iron content in groundwater of Bangladesh and evaluate suitability of groundwater for drinking (Hossain and Huda, 1997).

Analysis of the iron content in ground water of Bangladesh

Data collection: The data considered here were collected from the various agencies involved in the work of groundwater. Mainly these data were collected from Environmental Engineering laboratory, BUET, Dhaka and Bangladesh water Development Board (Ground water circle), Dhaka. These data were compiled according to the administrative districts of Bangladesh. Maximum 50 numbers of water quality data have been found for Chittagong district and minimum 4 numbers of water quality data have been found for Sariatpur, Habigang and Chandpur districts. Locations of those collected samples have been shown in **Figure-1**.

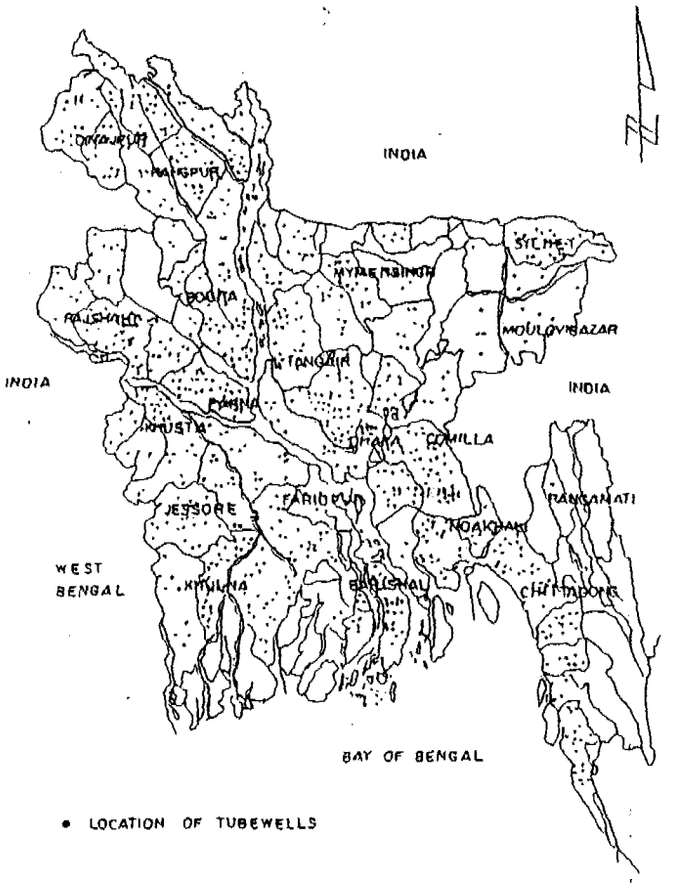


Figure 1 Location of the observed deep tubewells of Bangladesh.

Ground water quality data analysis : In this analysis , iron content in ground water has been compared with the Bangladesh water quality standard for drinking. Ground water quality data of about 1000 deep tubewell samples from about 124000 sq. km. area which covers 56 administrative districts of Bangladesh out of 1444000 sq. km. area of 64 administrative districts were analysed. Inadequate information are available for about 20000 sq. km. area (rest 8 districts) of Bangladesh. Allowable limit of iron in water for drinking in Bangladesh is 0.3 - 1. 0 mg/1. The limit may be considered upto 5. 0 mg/L for areas with no alternative suitable drinking water sources. Two analysis performed with the help of GIS are presented in Figure 2 and 3. Fog. 2 shows areas with iron concentration exceeding 1 mg/L and Fig. 3 shows those exceeding 5mg/L. From Fig. 1, it is observed that iron problem exists in almost all areas of Bangladesh. Groundwater of about 51,000 sq. km. (41%) of the studied area contains more than 1.0 mg/l of iron. Whereas about 28,000 sq.km. (22.5%) of the studied area contains iron more than 5.0 mg/l. Iron problem is acute in ground water in the districts of Manikgonj, Gopalgonj, Narshingdi, Narayangonj, Rajshahi, Bagerhat, Sylhet, Sunamgonj, Noakhali, Khulna and Kurigram. The people in the problem areas use tubewell water having 4.0 mg/l of iron without much hesitation but water of such quality is not acceptable in other region of the country. The major causes of the non-usage of water with excessive iron are bad taste and odour, stickiness of hair and roughness of skin and also it makes the teeth and nail black and weak. Iron removal plant is essential for the above mentioned iron problem areas of Bangladesh. Aeration, coagulation/flocculation, sedimentation and filtration are required for a large scale treatment process.

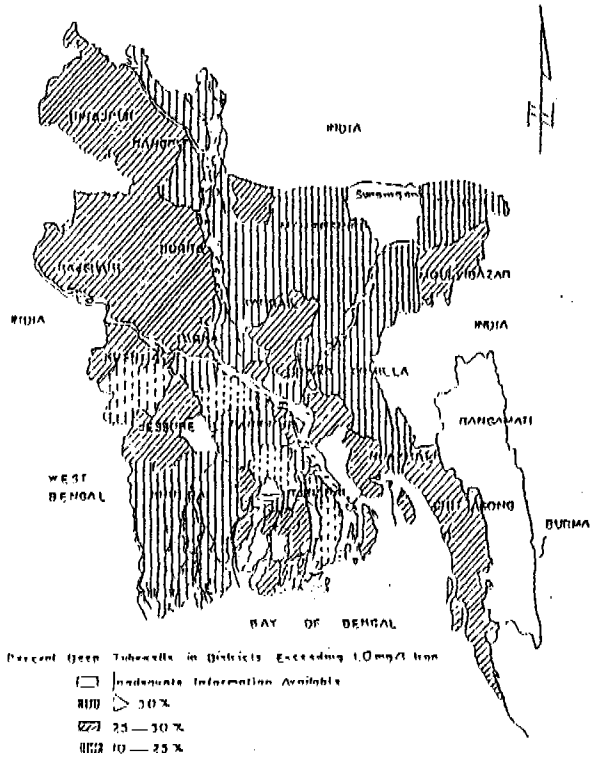


Figure 2 Iron content in deep tubewell water of Bangladesh (Iron > 1.0mg/l).

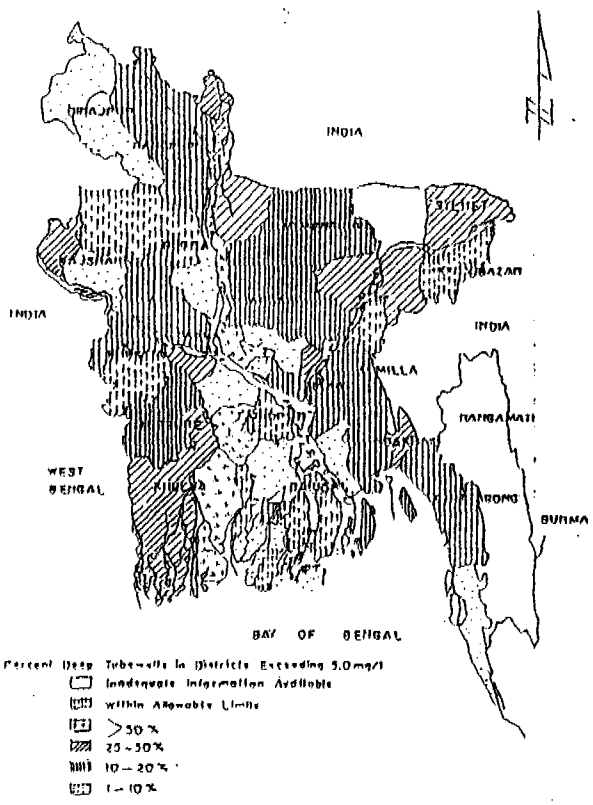


Figure 3 Iron content in deep tubewells water of Bangladesh (Iron > 5.0mg/l)

9 IRON REMOVAL

Sources of Iron:

Iron exist in soil and minerals mainly as insoluble ferric oxide and iron sulphide (pyrite). It occurs in some areas as ferrous carbonate (siderite) which is very slightly soluble. Some ground waters usually contain significant amount of CO_2, appreciable amounts of ferrous carbonate may be dissolved by the reaction shown in the equation

$$FeCO_3 + CO_2 + H_2O \rightarrow Fe^{2+} + 2HCO_3^-$$

Removal Methods:

There are four general methods used for the removal of iron:

A. The primary method involves oxidation, precipitation followed by solid transfer (sedimentation and filtration).

B. The second method involves ion exchange

C. The third method involves stabilisation of iron in suspension using dispersing agents to prevent the deposition of iron.

D. Sub-surface aeration.

A. Oxidation, Precipitation followed by Flocculation, Sedimentation and Filtration.

The most popular method of iron removal involves oxidation of more soluble iron (II) to relatively insoluble iron (III) and subsequent removal of the precipitates thus formed by sedimentation and filtration.

***The Kinetics of Iron Oxidation*:**

- The rate of ferrous iron oxidation is of the first order with respect to ferrous iron concentration and the partial pressure of oxygen.
- The rate of oxidation remains unaffected by DO concentration, if the concentration exceed 5mg/l.
- Reaction rate are strongly pH dependent and there is a second order relationship, quite slow at pH 6.00 and very rapid at pH >7.5. Solubility of ferric hydroxide decreases with increasing pH only upto about 10.0.
- Oxidation reaction is incomplete and very slow for low alkaline water (<130 mg/l as $CaCO_3$). Within a pH range of 7.49 - 7.78 an increase of alkalinity from 395 to 610 mg/l as $CaCO_3$, causes a 10 fold decrease in half time.
- The rate increases about 10 fold for a 15°C increase in temperature.

- Chloride and sulphate ions have a significant retarding influence on the rate constant in the pH range from 6.5-7.2.
- Organic materials form complexes with ferrous iron which is resistant to oxidation, even in the presence of DO.
- For a given pH and DO concentration, the addition of as little as 0.02 mg/l of Cu^{2+} reduces the oxygenation time by a factor of 5.

Solubility of Iron:

Iron is chemically reduced, **soluble**, invisible in **ferrous form** (Fe^{+2}) and may exist in tubewell waters or anaerobic reservoir bottom water under the following conditions:

– In absence of DO, at high CO_2 concentration, at low pH, low alkalinity and complex w ith organic materials

Iron is oxidised, **insoluble**, visible in **ferric form** (Fe^{+3}) under the following conditions:

– In presence of DO, at low CO_2 concentration, at high pH, high alkalinity and in absence of organic
materials

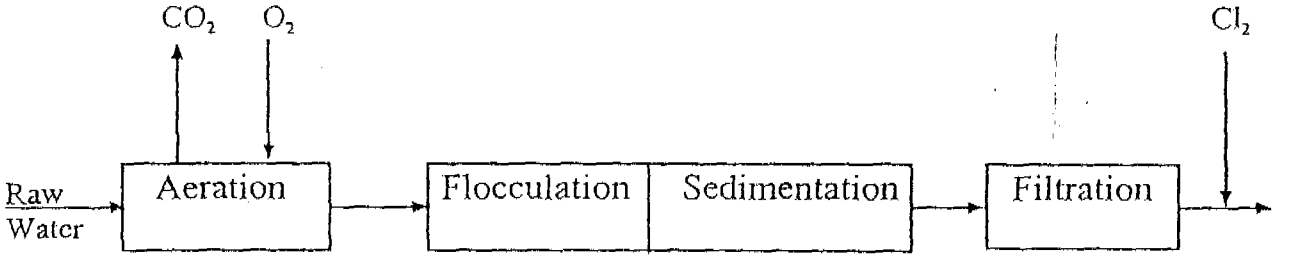
(a) **Oxidation through Simple Aeration -**

The simplest form of iron oxidation is plain aeration. Stoichiometrically 0.14 mg/l of O_2 is required to oxidise 1.0 mg/l of Fe.

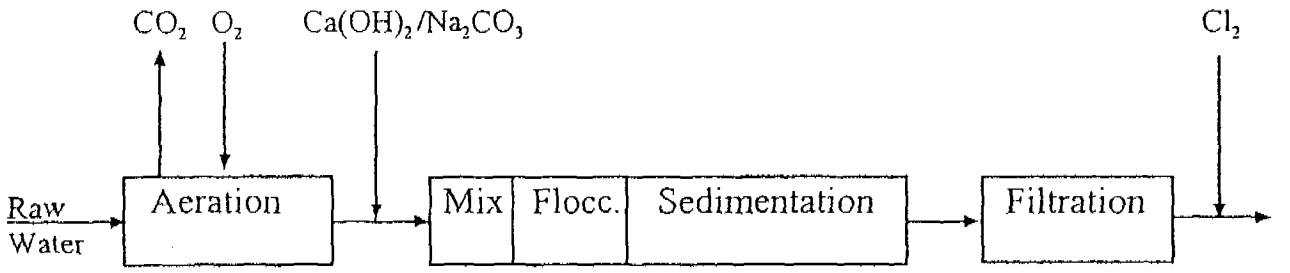
$$4Fe(HCO_3)_2 + O_2 + H_2O \rightarrow 4\,Fe(OH)_{3(s)} + 9CO_2$$

Removal Under Different Environmental Conditions:

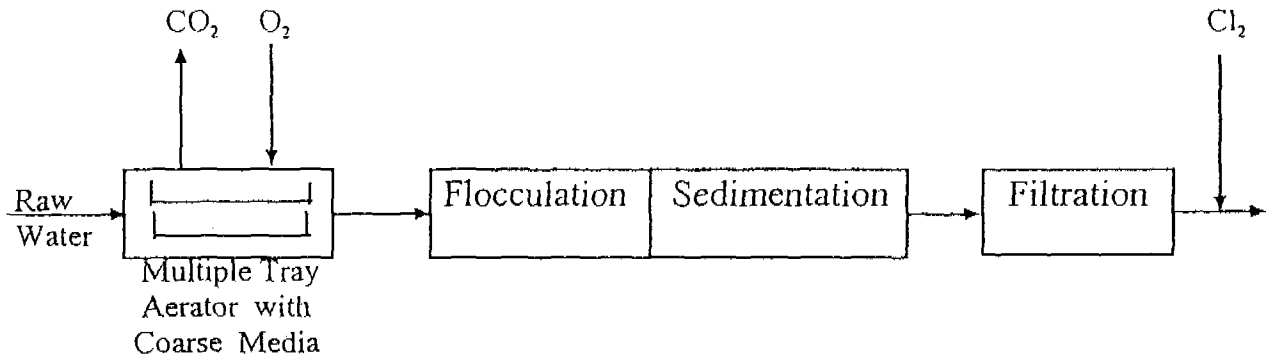
1. Iron alone in ground waters which **contains little or no organic matter with reasonable alkalinity** when aerated CO_2 and H_2S are released raising the pH and oxidised to insoluble iron.



2. **Low alkalinity** water (< 130 mg/l as $CaCO_3$) needs some chemical additive to raise both pH and alkalinity like lime [$Ca(OH)_2$], soda ash [Na_2CO_3] etc. If the water is softened by addition of lime, additional benefits include removal of iron. Aeration prior to lime addition reduces the cost of chemicals through CO_2 reduction.

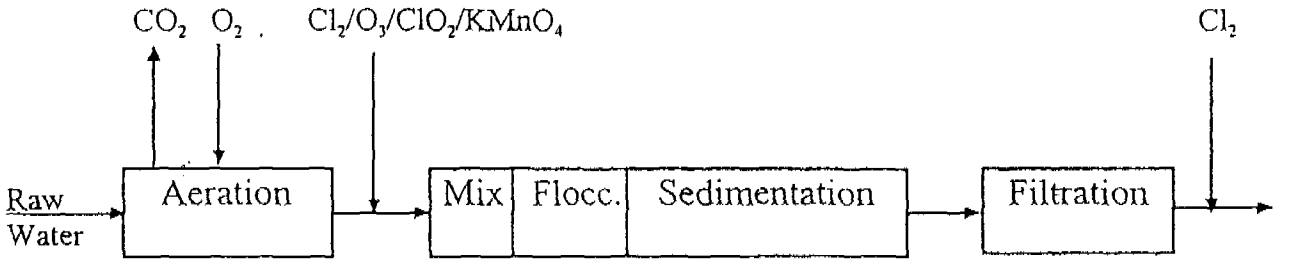


3. If the water **contains organic matter** such as humic or fulvic acid and if **the alkalinity is low,** aeration is sufficiently rapid only if it is catalysed by accumulation of oxidation products (Fe_2O_3) on a porous bed (aeration tower containing trays with coarse media). Iron is removed from solution by adsorption on the bed. Organic material interferes with removal by forming soluble complexes.



(b) **Aeration and Chemical Oxidation-**

Preliminary aeration strips out dissolved gases and adds oxygen. In low alkaline or organic content water, the application of strong oxidising agents such as chlorine, ozone, chlorine dioxide, or potassium permanganate can serve to modify or to destroy the organic material and to oxidise iron more rapidly. 0.94 mg/l of potassium permanganate and 0.64 mg/l of chlorine is required per 1.0 mg/l of iron respectively.



(c) **Biological Oxidation-**

Gallionella ferruginea , *Leptothrix* and other iron bacteria are capable to oxidise iron.

Solid transfer:

Effective flocculation, sedimentation and filtration following chemical oxidation is essential, since a significant amount of the flocculated metal oxides are not heavy enough to settle by gravity. Direct filtration is not always recommended to avoid frequent clogging of filter bed, particularly when the concentration of iron is high (> 5 mg/l).

B. Ion Exchange:

Manganese zeolite is a natural green sand coated with manganese dioxide that removes soluble iron from solution. After the zeolite becomes saturated with metal ions, it is regenerated using $KMnO_4$. Cation-exchange resins will remove iron, but care must be taken to ensure that it remains in the reduced state, otherwise, it will form coating on the resin reducing the exchange capacity

C. Stabilisation:

Sodium hexa-metaphosphates at dosages of 5 mg per mg of Fe and Mn are used for this purpose. This process is limited for Fe + Mn concentration upto 1.0 mg/l.

D. In situ (Sub- surface) Aeration:

Iron may be treated in situ by pumping oxygenated water into a metal-rich aquifer. The iron is evidently oxidised and precipitated within the aquifer and are deposited upon the sand in a manner, which does not cause clogging.

MANGANESE REMOVAL:

Manganese is much more slowly oxidised through aeration than iron. In fact, the rate is negligible at pH levels below 9.0. Chemical oxidation of Mn requires a pH level above 8.5 and 1.0 mg of chlorine can oxidise 1.3 mg of Mn.

8 MICROBIAL QUALITY AND IMPROVEMENT

Microbial Quality of Water:

Microorganisms are commonly present in surface water, but they are usually absent from ground water, because of their filtering action of the aquifer. The most common microorganisms in water are bacteria, fungi, protozoa, helminths(worms),viruses and algae. Many communicable diseases are transmitted by water due to presence of these organisms.

Bacteria - are single celled organism with varying in shape and size from about 1 to 4 μm. Disease-causing bacteria are called pathogenic bacteria. The bacterial diseases include typhoid, paratyphoid, bacillary disentery, asiatic cholera, etc. *Escherichia Coli* are bacteria that inhabit the intestines of warm-blooded animals and humans are excreted with feces and their presence in water is taken as an indication that pathogenic bacteria may be present.
Fungi- are aerobic, multicellular, non-photosynthetic and chemoheterotrophic protists. Ecologically, fungi have two advantages over bacteria; they can grow in low-moisture areas, and they can grow in low-pH environments. Certain fungi, notably *Aspergillus*, are human pathogens.
Protozoa- They feed on bacteria and other microorganisms. Protozoans such as *Giardia* and *Cryptosporidium* can produce gastroenteritis and are very resistant to disinfectants.
Worm- Schistosomiasis is caused by a worm which may be transmitted through water via a snail carrier.
Viruses- are obligate parasitic particles which do not have the ability to synthesize new compounds. Viral diseases associated with water include hepatitis, poliomyelitis and gastroenteritis etc.
Algae- can be a great nuisance in surface waters because they produce large floating colonies called blooms. Lakes with annual total nitrogen and phosphorus concentration greater than 0.8 mg/l and 0.1 mg/l. respectively, exhibit algal blooms and nuisance, weed growth during most of the growing season. They often cause taste and odor problems.

Sanitary Protection:

Organisms which cause infectious diseases are normally spread through the fecal and urinary discharges of sick person and carriers. Protection of water supplies against these agents is thus normally a matter of preventing discharges of human wastes and inadequately treated waste water into the source.

Water Quality Improvement:

(a) Natural Process- Most pathogens are accustomed to live in the temperatures and conditions found in the bodies of humans and animals. They do not survive well outside the body. Storing water for extended periods in open tanks or reservoir prior to treatment can accomplish some destruction of pathogens through sedimentation and natural die-off of the organism. More than 50% of the pathogen in water will die within 2 days and 90% will die by the end of one week.

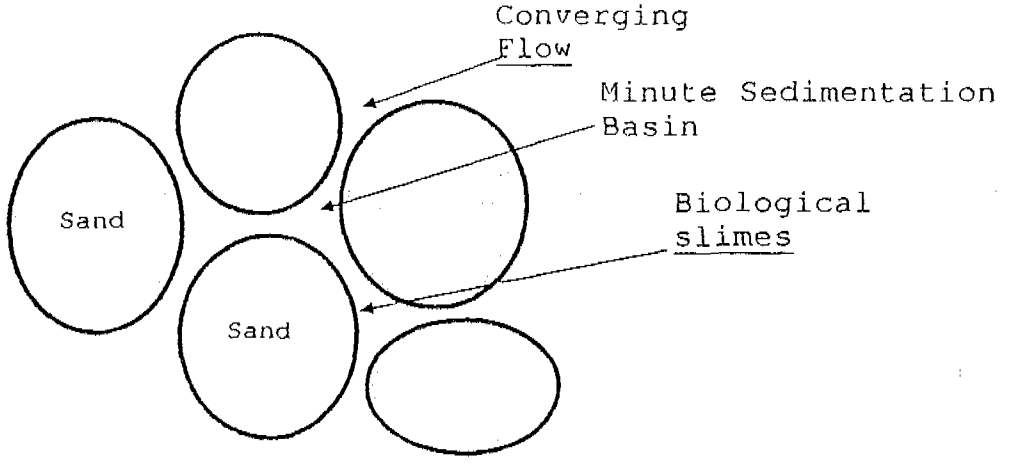
(b) Conventional Treatment-

Significant pathogens removal also occurs during the conventional treatment processes of coagulation, flocculation, sedimentation and filtration. Typical bacterial and viral reduction in coagulation- flocculation processes are 60-70% and addition of a filtration process increases the over all removal to close to 99%.

Coagulation Process (Sweep floc) -During coagulation and flocculation processes bacteria are entrapped in a floc or enmeshed by its 'stick' surface as the flocs settle at the bottom of the settle tank. Removal of *Giardia* in coagulation is closely associated with removal of turbidity (65 - 90%). Removal of hepatitis A virus and rotavirus are typically in excess of 90%.

Softening Process- **Extreme values of pH,** either high during softening process or low, during alum coagulation process can provide good bacterial kills. Precipitation of Mg (at pH value around 11.0) can give coliform reduction of more than 99.9%.

Filtration Process- The filter media are very efficient in retaining finer and colloidal particles including bacteria. Converging flow across the interstices, increases the probability of contact between the small particles to form flocs.The interstices between the sand grains act as a minute sedimentation basin in which the suspended particles, colloids,bacteria settle upon the sides of the sand grains and adhere because of the presence of gelatinous coating (biological slimes of SSF or coagulant floc layer of RSF)on filter media. Adhesion of bacteria on gelatinous coating (top layer) form a Zoogleal film around sand grain in which biological activities are carried out (detain bacteria and remove organic matter in SSF).



Slow sand filtration has been clearly demonstrated to be capable of complete removal of *Giardia* after ripening. In addition it provides excellent removal of coliforms, other bacteria and viruses. The length of filter run can be increased by pre-treatment by passing the water through a series of coarse gravel ranging from 6 - 20 mm, which can reduce the turbidity from over 100 to less than 10 NTU.

In Rapid sand Filter coagulated floc [$Al(OH)_3$] form a chemical layer on the filter media which is also gelatinous in nature. Bacteria are removed due to adhesion/adsorption on this layer.

In Rapid sand Filter coagulated floc [$Al(OH)_3$] form a chemical layer on the filter media which is also gelatinous in nature. Bacteria are removed due to adhesion/adsorption on this layer.

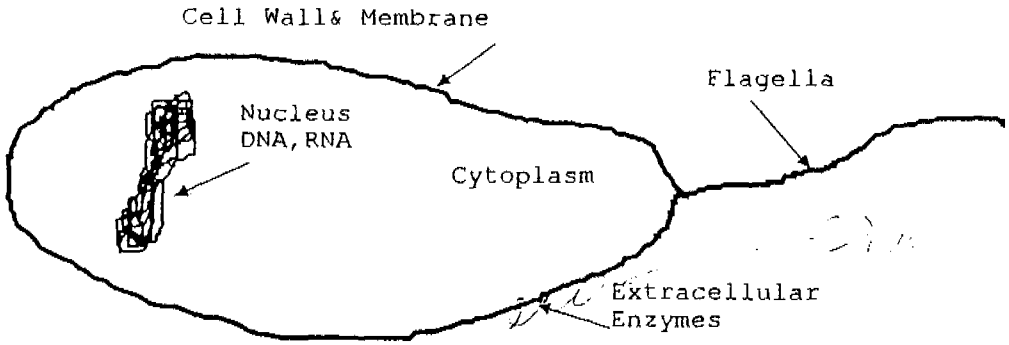
(c) **Disinfection -**

Is the killing of disease-producing micro-organisms. It provides additional protection against transmission of diseases. The rate of kill is a function of concentration of disinfectant and exposure time,

$$\text{Kill} \propto c \times t$$

Viruses, cysts, and ova are more resistant to disinfectants than are bacteria. Disinfectants include chemical agents such as the halogen group, ozone, or metallic ion; irradiation with gamma waves or ultraviolet light; and sonification, electrocution, heating, or other physical means.

Chlorination- is the most common means of disinfecting water and usually performed as the final treatment process. The mechanisms by which chlorine kills disease-causing organisms is uncertain. It is likely that the chlorine destroys the extracellular enzymes of the bacteria's and possible that it actually passes through the cell wall to attack intercellular systems.



At higher concentrations, oxidation of cell wall will destroy the organism. Other factors affecting the process are- form of chlorine (HOCL), pH(low), type of organisms, temperature and turbidity(low) of water.

Ozone- It is a strong oxidising agent. Unlike chlorine it requires a very little contact time. Contact times for viruses inactivation are reported as little as 2 minutes. The disadvantage is that no residual remains in this process of disinfection.

Potassium permanganate- is also a strong oxidising agent and exhibits germicidal properties.

Ultraviolet irradiation- With a wave length of 253.7 nm it is effective in killing all types of bacteria and viruses through the probable mechanism of destruction of nucleic acids (DNA,RNA). The UV energy is absorbed by the genetic material of the cells.

Ultrasonic waves- at frequencies of 20 to 400 kHz have been demonstrated to provide complete sterilisation of water at retention times of 60 minutes.

Metallic ions- such as silver (0.05 mg/l), copper and mercury exhibit disinfecting action.

Heat- can be used to disinfect water by boiling for 5-20 minutes.

(d) Control of Carbon & Nutrient sources-

There are four basic requirements of life. The growth of organisms can be stopped / ceased through controlling any one of these parameters.

Source of Carbon: Organic carbon(Heterotrophic), $C_xH_yO_z$
Inorganic carbon (Autotrophic), CO_2

Source of Energy: Chemical oxidation/reduction reaction (Chemosynthetic)
Sun light (Photosynthetic)

Source of Nutrient: N, P and other trace elements(Fe,Na,K,Ca,S etc.)

Source of Respiratory Oxygen(Aerobic): Molecular oxygen

Algae Control

The only effective means of preventing algae growth is nutrients (Nitrogen and Phosphorus) control. Nitrogen and phosphorus are mainly contributed to surface waters from man generated wastes (feces, urine,food wastes,synthetic detergents etc.) and run off from agricultural land (fertiliser). The general acceptable upper concentration limits for lakes free of algae nuisances are 0.3mg/l of inorganic nitrogen and 0.02mg/l of orthophosphate phosphorous at the time of spring overturn. Several temporary controls have been used to reduce the algae growth:

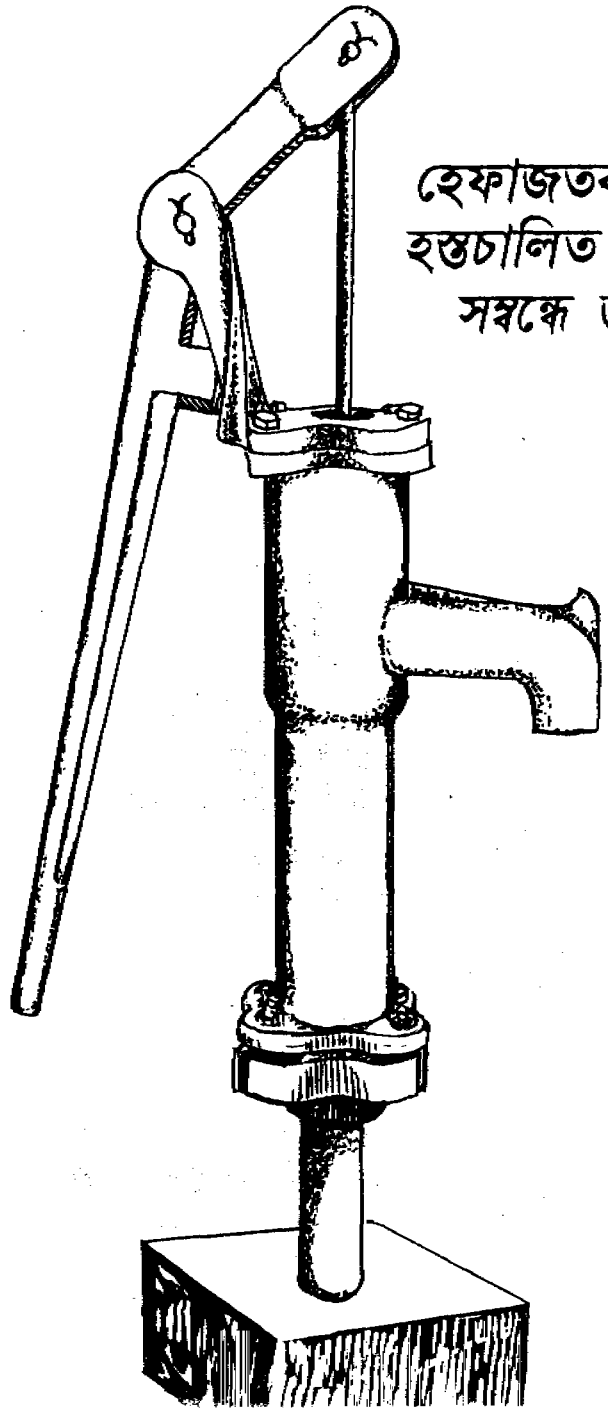
- Chemical control (algaecide)
  Both copper sulphate(usually 0.1-0.5mg/l) and chlorine(0.3-1.0mg/l) have been used to control algae.

- Artificial mixing / Artificial destratification

- Algae harvesting

প্রকল্প পরিচালক, জনস্বাস্থ্য প্রকৌশল অধিদপ্তর
ওলন্দাজ সাহায্যপুষ্ট পানি সরবরাহ ও পয়ঃ নিষ্কাশন প্রকল্প,
১৯০, আরামবাগ, ঢাকা-১০০০

হেফাজতকারীদের জন্য হস্তচালিত ৬ নং নলকূপ সম্বন্ধে জানার বিষয়



Training of Technicians & Caretakers.

নেদারল্যান্ড বাংলাদেশ উন্নয়ন সহযোগীতা কার্যক্রম

ডি পি এইচ ই - পানি সরবরাহ এবং পয়ঃ নিষ্কাশন প্রকল্প

১৮ জেলা শহর পানি সরবরাহ, পয়ঃ নিষ্কাশন এবং নর্দমা নির্মান প্রকল্প

হেফাজতকারীর নাম ঃ

স্বামী/পিতার নাম ঃ

গ্রাম/পাড়া ঃ

ওয়ার্ড ঃ

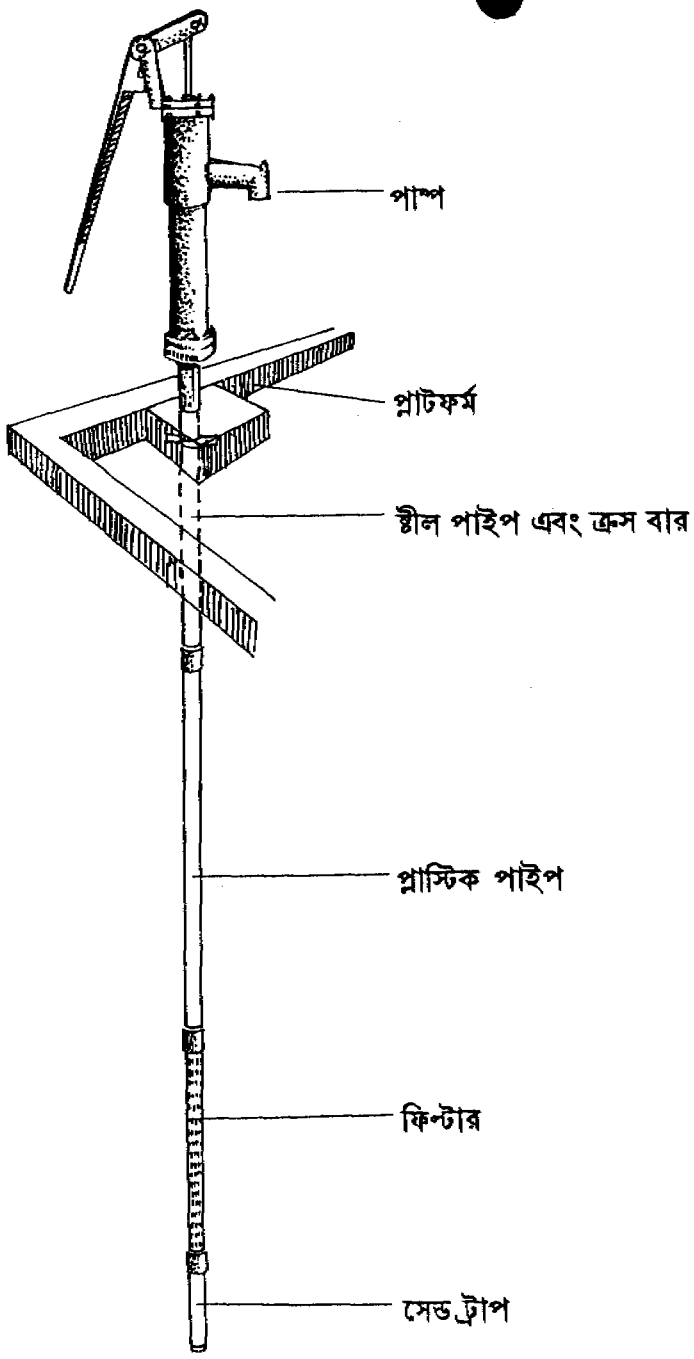
নলকূপের গভীরতা ঃ

ফিল্টার সাইজ ঃ

ফিল্টারের দৈর্ঘ্য ঃ

নলকূপ স্থাপনের তারিখ ঃ

অন্যান্য তথ্যসমূহ ঃ



নলকূপ হেফাজতকারীর দায়িত্ব ও কর্তব্য

ক. নলকূপ স্থাপনের সময় কি করতে হবেঃ

১। খেয়াল রাখুন নলকূপটি যেন উপযুক্ত স্থানে স্থাপিত হয় যেখানেঃ

- সুবিধাভোগকারী দলের সকলের সম্মতি আছে
- সবাই নলকূপটি সকল সময় ব্যবহার করতে পারে
- হেফাজতকারী নলকূপটির তত্বাবধায়ন করতে পারে
- নিকটবর্তী পায়খানা (বা ভবিষ্যতে নির্মিতব্য) থেকে দূরে থাকে
- উচুঁ স্থান ও ভালো ড্রেন ব্যবস্থা আছে

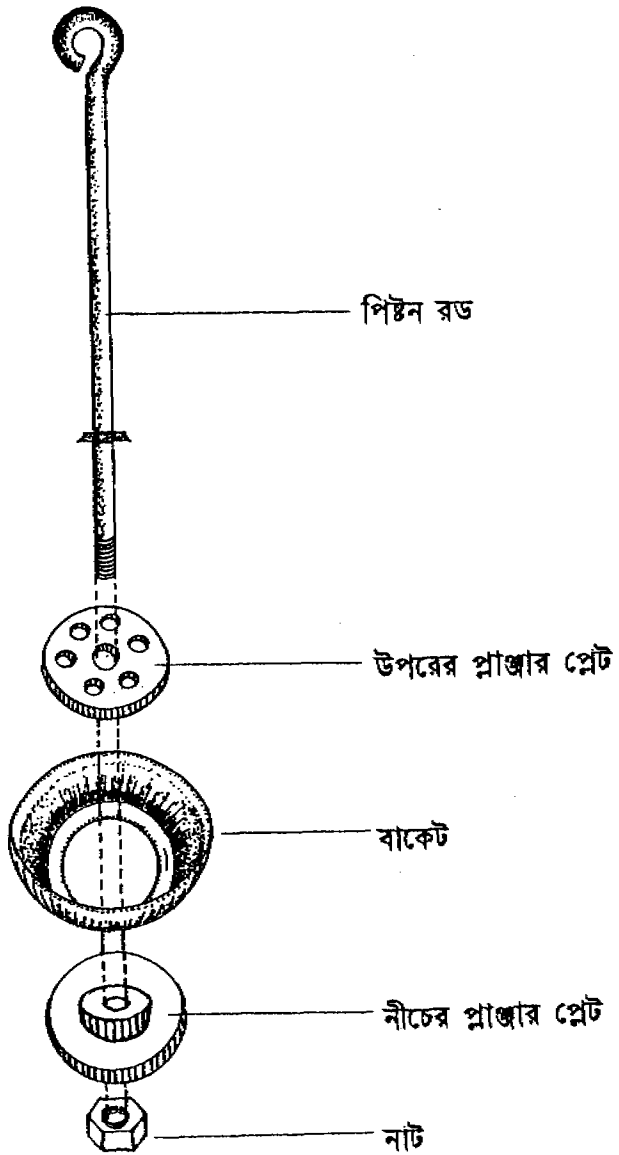
২। নলকূপ স্থাপনের সময় আনুষাঙ্গিক মালামালের দিকে লক্ষ্য রাখুন

৩। খেয়াল রাখুন যেন নলকূপের পাটাতনটি সঠিক ভাবে নির্মিত হয়ঃ

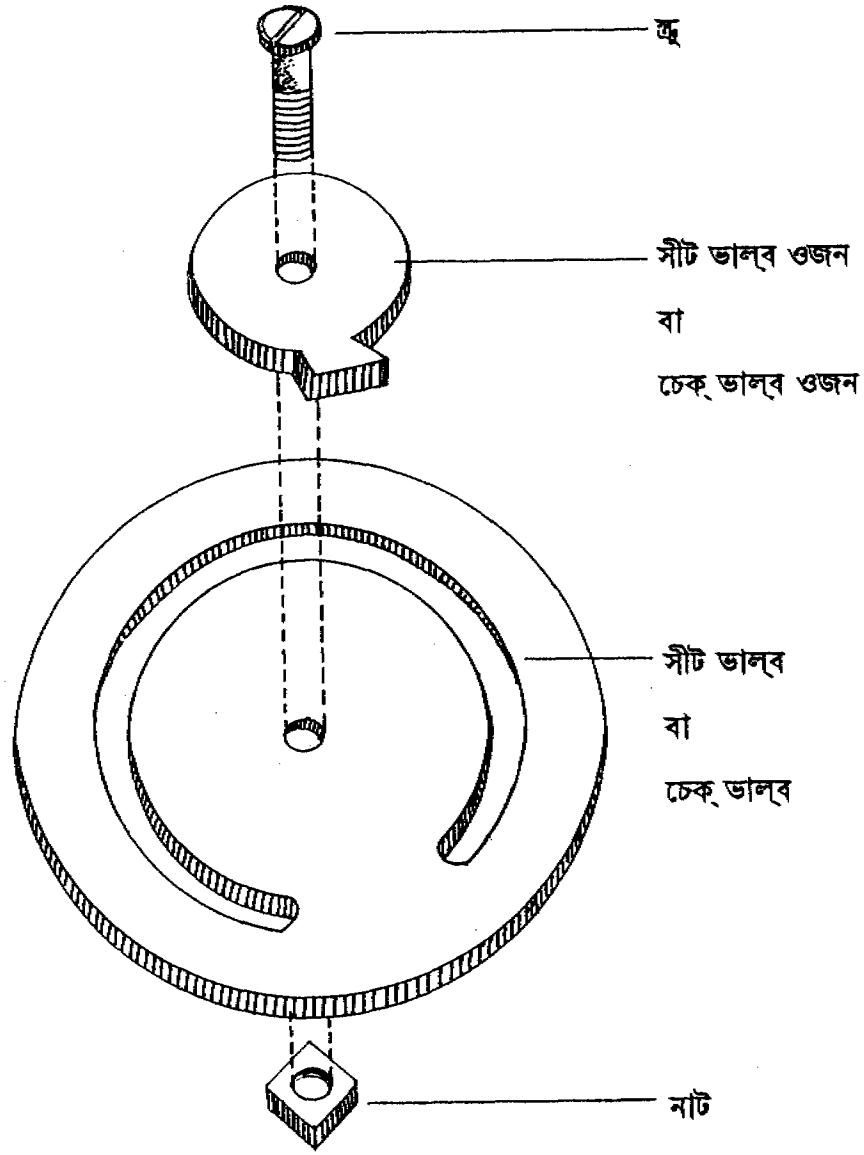
- সহজ ব্যবহার যোগ্য হয়
- পর্যাপ্ত ভাবে ঢালু হয় (পাটাতনে এক বালতি পানি ঢাললে তা সম্পূর্ণভাবে নিষ্কাষিত হবে)
- উপযুক্ত ভাবে ঢালাই করা হয়

৪। নলকূপের পাটাতন ড্রেনের শেষ প্রান্ত থেকে কিছুটা কাঁচা ড্রেন তৈরী করুন যেন পাটাতনের পানি নিকটবর্তী ডোবা, পুকুর বা বাড়ীর আঙ্গিনায় সব্জি বাগানে যেয়ে পড়ে

প্লাঞ্জার এসেমবলি



সিট ভাল্‌ব এসেমবলি



নলকূপ হেফাজতকারীর দায়িত্ব ও কর্তব্য

খ. নলকূপের ব্যবহারের সময় কি করতে হবেঃ

১. দলের প্রতিটি সদস্যের বাড়ীর লোকজনকে নলকূপের পানি পান করতে বলুন এবং রান্না, থালা বাসন ও কাপড় ধোয়া এবং গোসলের জন্য নলকূপের পানি ব্যবহার করতে উদ্বুদ্ধ করুন।

২. সব সময় নলকূপ, পাটাতন ও এর আশেপাশের স্থান পরিস্কার রাখতে সচেষ্ট থাকুন।

৩. খেয়াল রাখুন যেন পাটাতনের ড্রেনে বা সংযুক্ত কাঁচা ড্রেনে পানি কোন সময়েই আটকে না থাকে।

৪. সব সময় খেয়াল রাখুন যেন বাচ্চারা নলকূপের প্লাটফর্মের উপরে খেলাধূলা না করে এবং নলকূপের ভিতর কেউ কোন কিছু না ফেলে।

৫. প্রতি ৬ (ছয়) মাস পর নলকূপের নাট বল্টু ও এম এস বার এ নিয়মিতভাবে গ্রীজ/তেল লাগান।

৬. নলকূপের হারিয়ে বা ভেঙ্গে যাওয়া যন্ত্রাংশ নূতন করে লাগিয়ে ফেলুন।

৭. যদি নলকূপে পানি না থাকেঃ

- অন্য আর একটি নলকূপ থেকে পানি এনে আপনার নলকূপে ঢালুন।

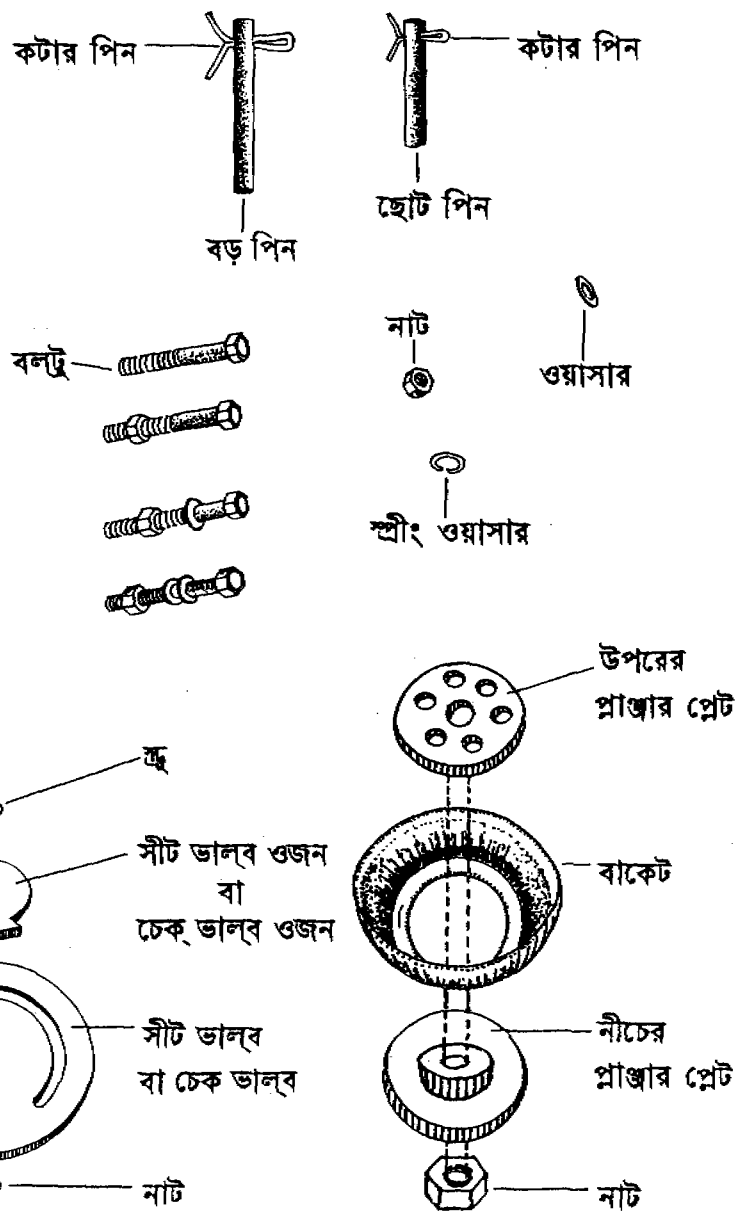
  যদি এর পরও নলকূপ কাজ না করেঃ

- নলকূপ খুলুন। ক্ষতিগ্রস্থ বা ক্ষয়ে যাওয়া যন্ত্রাংশ মেরামত বা বদল করুন।

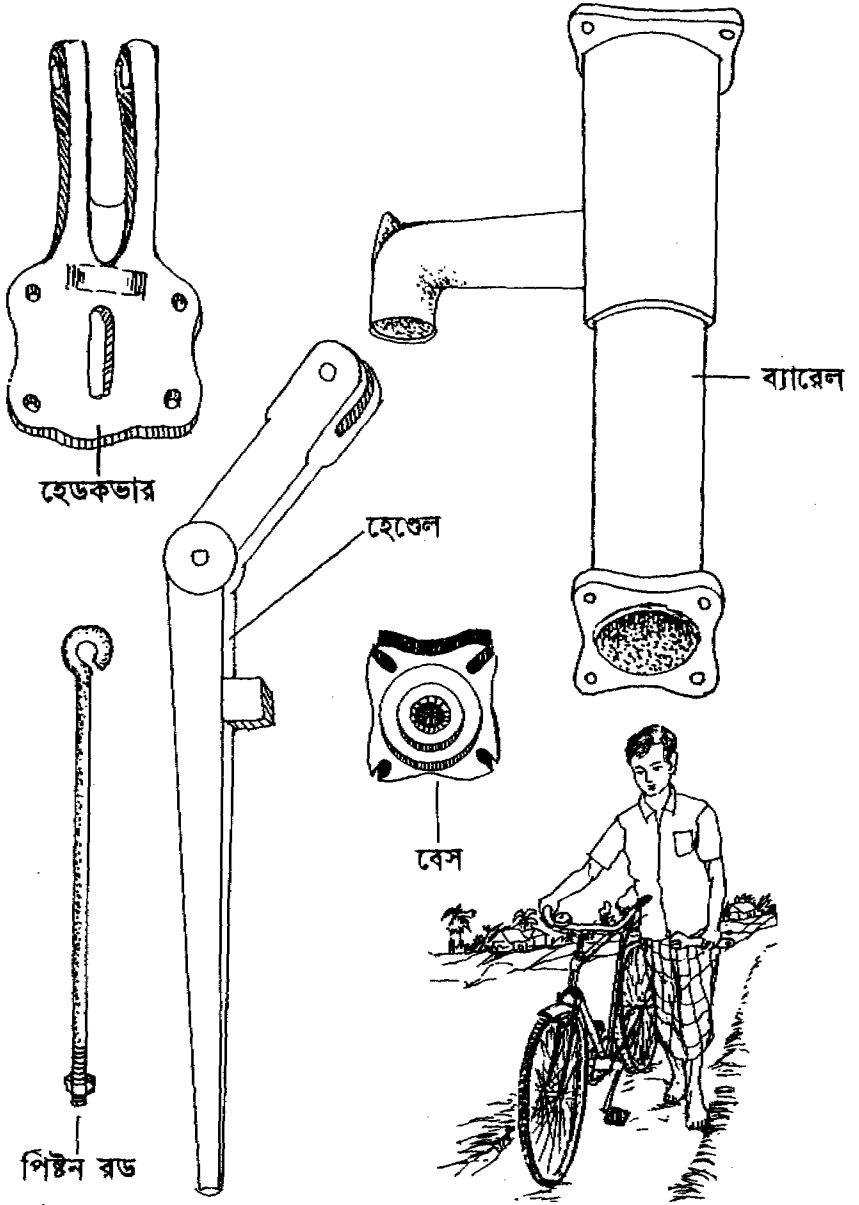
  যদি এর পরও নলকূপ কাজ না করেঃ

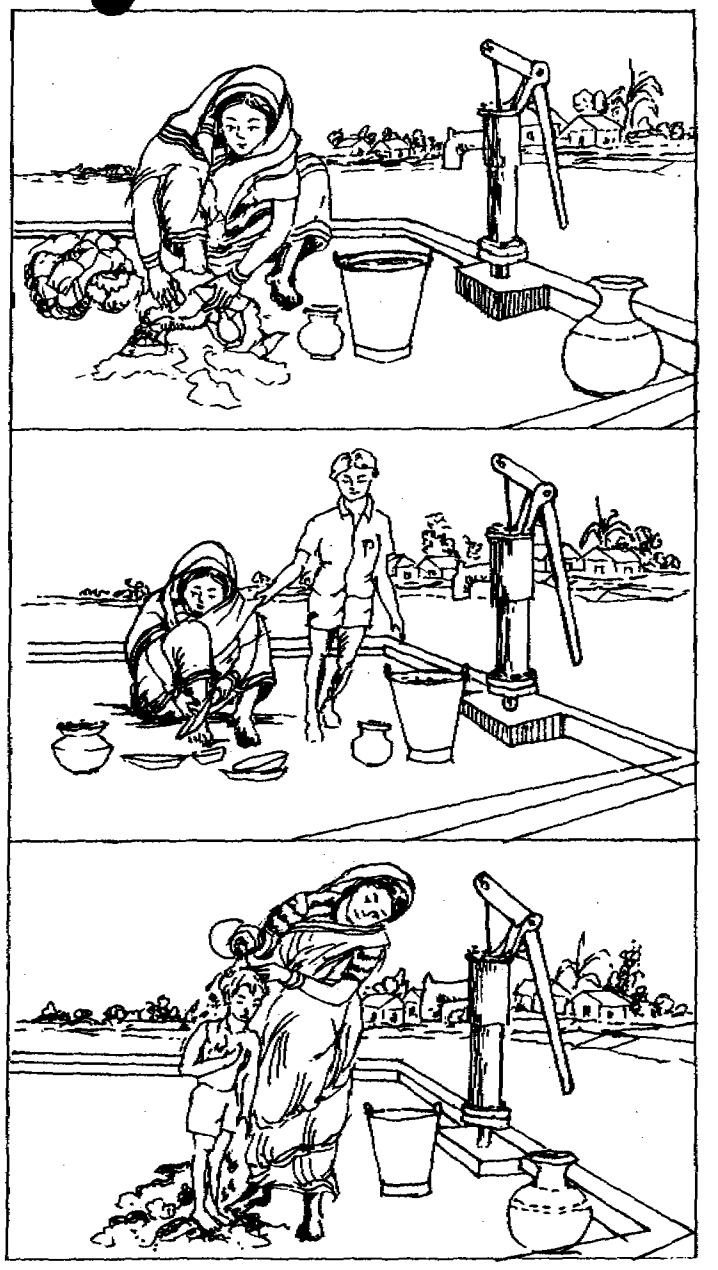
- পৌরসভার নলকূপ মেকানিককে খবর দিন।

প্রয়োজনে ক্ষুদ্র যন্ত্রাংশ গুলো নিজেদের ব্যায়ে নিজেরা মেরামত করুন

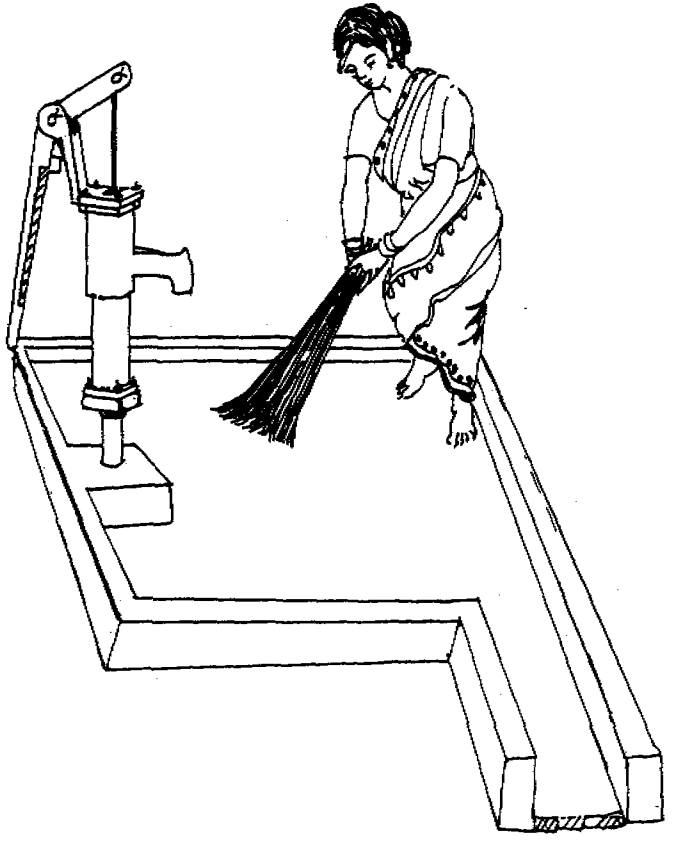


প্রয়োজনে বড় যন্ত্রাংশ গুলো মেরামতে
নলকূপ মেকানিকের সাহায্য নিন





১) দৈনন্দিন সকল কাজে নলকূপের পানি ব্যবহার করুন



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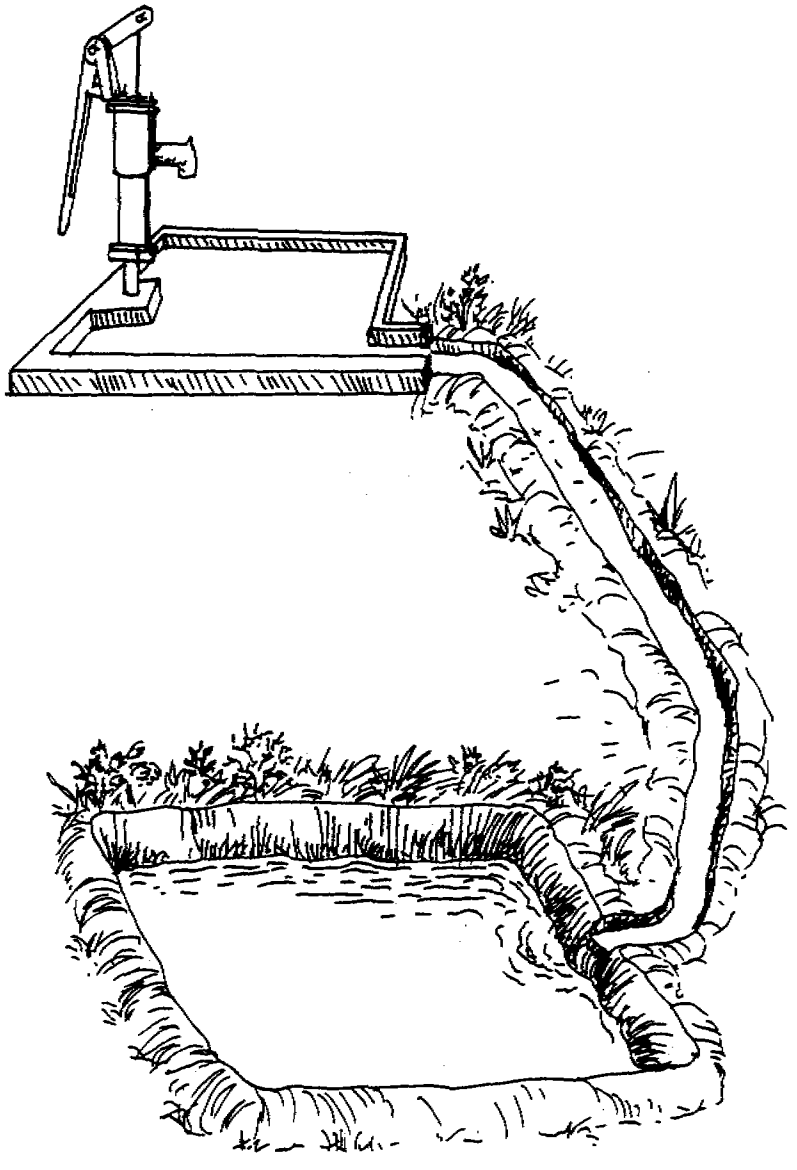

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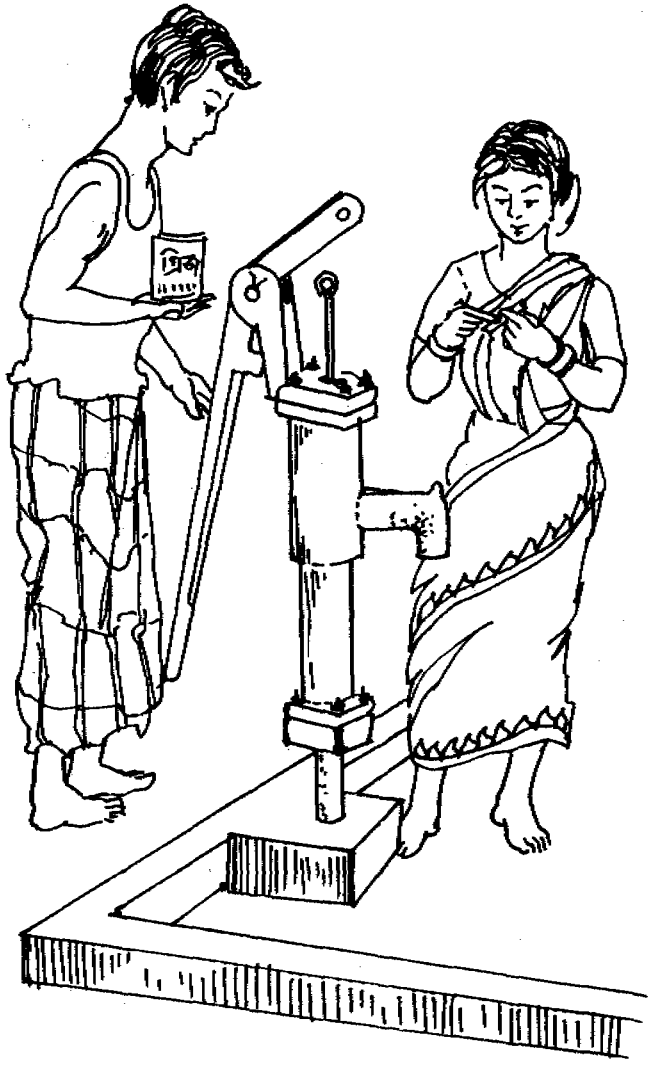

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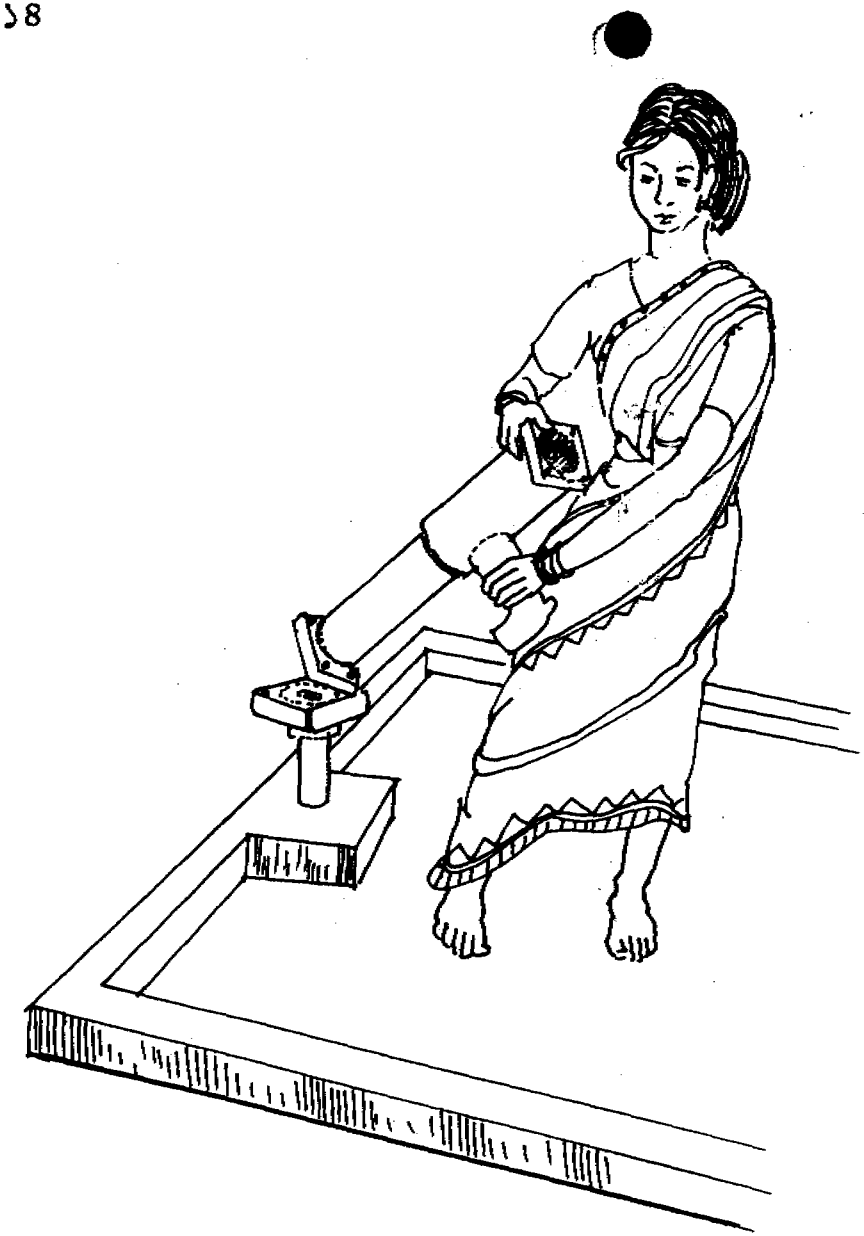

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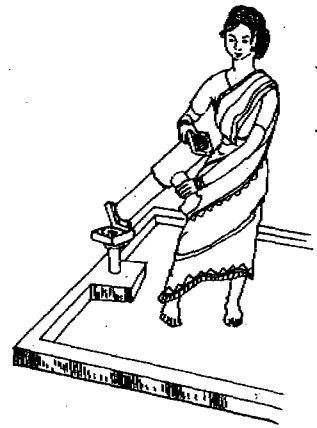
৭) যদি নলকূপে পানি না থাকেঃ

– অন্য আর একটি নলকূপ থেকে পানি এনে আপনার নলকূপে ঢালুন।



যদি এরপরও নলকূপ কাজ না করেঃ

– নলকূপ খুলুন। ক্ষতিগ্রস্থ বা ক্ষয়ে যাওয়া যন্ত্রাংশ মেরামত বা বদল করুন।

যদি এরপরও নলকূপ কাজ না করেঃ

– পৌরসভার নলকূপ মেকানিককে খবর দিন।

অসুবিধা	কি করতে হবে
১। কটার পিন হারিয়ে বা ভেঙ্গে গেলে	— নূতন কটার পিন লাগান
২। এম, এস বার ক্ষয়ে গেলে	— নূতন এম এস বার লাগান
৩। নাট বা বল্টুতে খুব বেশী জং ধরলে বা তা হারিয়ে গেলে	— নূতন নাট ও বল্টু লাগান
৪। হ্যান্ডেল ভেঙ্গে গেলে	— পৌরসভার নলকূপ মেকানিককে ডাকুন
৫। নলকূপের মাথা ভেঙ্গে গেলে	— পৌরসভার নলকূপ মেকানিককে ডাকুন
৬। পাম্প করার পর পানি না বের হলে	— ১) অন্য নলকূপের পানি এনে আপনার নলকূপে ঢালুন ২) নলকূপের গোড়ায় বা বেস এর নাট বল্টু শক্ত করে লাগান ৩) পাম্প খুলুন এবং ক) জি আই স্ক্রু ও নাট শক্ত করে লাগান খ) সিট ভাল্‌ব বদল করুন (যদি ক্ষয়ে যায়) গ) প্লাঞ্জার ঠিকমত লাগানো আছে কি—না পরীক্ষা করুন ঘ) বাকেট বদলান (যদি ক্ষয়ে যায়) ঙ) প্লাঞ্জার প্লেট বদল করুন (যদি ক্ষয়ে যায়)
৭। পিষ্টন রড থ্রেড ক্ষয়ে গেলে	— পৌরসভা নলকূপ মেকানিককে ডাকুন
৮। ব্যারেল ভেঙ্গে গেলে	— পৌরসভা নলকূপ মেকানিককে ডাকুন
৯। বেস ভেঙ্গে গেলে	— পৌরসভা নলকূপ মেকানিককে ডাকুন

নতুন নলকূপ স্থান নির্বাচন নির্দেশীকা

* কেবল মাত্র নিম্নলিখিত নিয়ম ও নীতিমালা মানিয়া নলকূপের স্থান নির্বাচন করিলে কর্তৃপক্ষ উহা মঞ্জুর করিবেন।

১) যে সকল মহল্লা/পাড়া/বস্তিতে নলকূপ নাই সে গুলিকে প্রাধান্য দিতে হইবে।
২) চালু অথবা বন্ধ নলকূপ হইতে ১৫০ ফুট এর মধ্যে কোন নুতন নলকূপ স্থান নির্বাচনে প্রাধান্য পাইবে না (ঘনবসতিপূর্ণ এলাকা এ নিয়মের ব্যতিক্রম হইতে পারে)।
৩) উপকারভোগী এবং মহিলাদের ব্যবহার নিশ্চিত করার জন্য সুবিধাজনক স্থানে নলকূপটির স্থান নির্বাচন করিতে হইবে। এই ক্ষেত্রে মহিলাদের মতামত প্রাধান্য পাইবে।
৪) কোন বাড়ির ভিতরের আংগীনায় নলকূপের স্থান নির্বাচন করা যাইবে না।
৫) কমপক্ষে ৭০ (সত্তর) জন উপকারভোগীর জন্য একটি নলকূপ বরাদ্দ করা হইবে।
৬) সরকারী/ আধা সরকারী/ বেসরকারী সংস্থার অফিসে/ প্রতিষ্ঠানে কোন নলকূপের স্থান নির্বাচন করা যাইবে না।
৭) অবস্থান দূষণমুক্ত এলাকায় নলকূপের স্থান নির্বাচন করিতে হইবে।
৮) বন্যা উপদ্রুত এলাকায় যে সকল স্থানে সাধারণ বন্যায় পানি উঠে না এমন স্থানে নলকূপের স্থান নির্বাচন করিতে হইবে।
৯) জনবসতির অতি নিকটবর্তী এলাকায় নলকূপটির স্থান নির্বাচন করিতে হইবে। যাহাতে নলকূপটির হেফাজতকারীর পক্ষে রক্ষনাবেক্ষণের সুবিধা হয়।
১০) বিত্তশালী ও ধনী ব্যক্তি নলকূপের জন্য আবেদন করিবেন না।

09 Human Waste Management

1.0 Introduction

Many cities in developing countries have no systematic and adequate sewerage & sanitary system. In those that do have a sewerage system, it typically serves only a small minority of the population. This lack of adequate sanitation system is already enormous problem and is certain to become much larger. The urbanisation of developing countries is proceeding at an astonishing rate. In 1950 the urban population of developing countries is less than 300 million and at the decade of nineties it's about 1.3 billion. In 1990 about 300 cities in world had population of more than one million, but by the year 2000 the number will have increase to 400. In 1990 there were 9 cities in developing countries with population greater than 10 million; by 2000 that number will have doubled (UN 1985). Bangladesh is also not exception from this scenario. Bangladesh also should have the appropriate plan to fulfil the increasing sewerage and sanitation demand of existing and next 20 years projected population. In order to achieve this projected sanitation demand, traditional as well conventional and improved sanitation approach should be adopted.

2.0 Conceptual Tools

Living process has been to get rid of unwanted materials. The biological process for ridding the body of wastes has been termed as excretion and occurs in different manner in all living bodies.

In case of Human Beings-

a) The Skin: Which is eliminated the unwanted water and salts, CO_2

b) The Lungs: Which is expelled CO_2 and H_2O

c) The Livers: It is an important detoxifying organ. Drained bile constituent into the alimentary canal.

d) The Kidneys: Purify the blood and expel the wastes through urinary systems.

e) The Intestinal Tract: Gets rid of salts, minerals, fats and indigestible materials, rejected as unsuitable part for food metabolic process.

Infectious diseases are transmitted by pathogens presents in human excreta. Therefore, proper sanitation system is necessary to carry human excreta back to nature, providing comfort and convenience to users, minimising risk to excreta related diseases, and creating less pollution to the environment.

The excreta of the alimentary canal are primarily consists of intestinal bacteria which comprise the most bulky portion of human waste.

Urine: 1.5 Litres get excreta daily by adult human body, has been mostly H_2O with dissolved nitrogenous wastes and salts. It also carries away foreign substances like drug and other toxins.

2.1 Disposal of the Wastes of Life

When no more than 100,000 people populated the earth during ice age, human excretion was no particular problem. It was accomplished by walking to the woods or the rocks and leaving the waste for disposal by corprophagons (dung-eating) organisms.

Nature has several answers to the population problem:

a) Due to the effect of overcongestion:

The waste products eventually become so concentrated that many of the organisms die out from toxins, disease, or abnormal behaviour. Some times they become cannibalistic. Some of them may survive by escaping to less congested areas.

b) Due to the Effect of Urbanisation:
Concentration of human in a cities aggravates the problem of waste disposal beyond that which can be solved by natural means.

c) It had been the invention of two most important entities for the improvement of sanitation:
i) Toilet Paper
ii) Water closet
iii) Urinals

3.0 Sanitation Technology Options

Sanitation facilities varies from place to place, country to country, depending on climate, latitudes, socio-economic conditions etc. In urban areas water borne sewerage system and a range of on-site options are used. Only Dhaka city has a limited sewerage system that covers 18% of the population. In rural areas and urban fringes, low cost sanitary latrines are preferred. Sanitary, latrines prevent spreading of excreta related diseases, reduce bad smell and cause minimum pollution to soil, underground water and environment.

A brief overview of various sanitation technology options is given in the following:

a) Pit Latrine Technologies
b) Pour Flash Technologies
c) Bucket Latrine
d) Vault Latrine
e) Aqua Privy
f) Septic Tank
g) Conventional sewerage System
h) Small Bore Sewer System

3.1 Pit Latrine Technologies

Pit latrine are the simplest of all on-site disposal systems. Pit latrine consists of a pit with a platform having a defection hole. Human excreta falls into the pit through squat hole.

a) *Pit latrine rural concept*: *In rural areas our country traditionally defecate into a* squat hole on a bamboo/wooden platform placed over a pit. This type of latrine is called home made latrine(Fig. 1) . Basically, this is not a recommended practice, however, it is much better than open defecation. Since home-made latrine is low-cost and can be easily constructed even by the family members, promotion of this type of latrines is sometimes encouraged though it is not fully sanitary. With little intervention, these type of latrines can be altered to be a hygienic one.
The simplest and cheapest improvement of a home-made pit latrine by providing with a prefabricated slab with a squatting pan is called a simple pit latrine.

Reed odourless earth closet(ROEC) is a modification of VIP latrine.

b) Design Consideration:

* The pit should be as large as possible, not more than 1.5m wide
* Soils permeability @2.5mm/hr are not suitable as the liquid portion of the excreta is unable to infiltrate into the soil.
* Pits in unstable soil must be fully lined, otherwise there is risk that the pit will collapse and the superstructure may fall into it. (A wide variety of materials can be used to line the pit; for example concrete blocks, bricks, cement-stabilised soil blocks, masonry, perforated oil drums, etc. the pit can also be strengthened against collapse by putting a ring beam around the upper part).
* Safe distance between pit and water source should at least 10m.

c) **Design of Pit Latrine**

* Step 1- Effective Pit Volume depends on the solids accumulation rate, the number of users and desired life of the pit.

V=CPN (1)

Where, V= Effective pit volume (m3¯)
C= Solids accumulation rate, m3/per capita/year
P= Number of users
N= Design Year

*Step 2- Solid accumulation : Excreta deposited into the pit has two essential components.

a) Liquid fraction of the excreta (mainly urine), together with small amount of water that enters the pit due to anal cleansing, washing the slab which ultimately infiltrates into the surrounding soil; and

b) Faecal solids in the excreta that are digested anaerobically to produce;
i) Gases such as CH_4, CO_2 and H_2S which are exhausted from the pit via the vent pipe;
ii) Soluble compounds which are either further oxidised in the pit or are carried into the surrounding soil by the infiltrating liquid fraction.

*Step 3 - i) In dry pits the solids accumulation rate varies between 0.03-0.06m®Object¯/person/year which is in wet pits 0.02 and 0.04.
Accumulation rates are lower in wet pits because biodegradation is faster under wet conditions.

* Step 4 - The solid accumulation rate is assumed as 0.04 and 0.06 m^3 /person/year in wet and dry pits respectively.

* Step 5 - The effective pit depth is calculated from effective pit volume.

Effective pit volume, **V= (m^2)h; or V=m^3** (2)
Where, d= diameter of pit (Assuming suitable diameter: P®Object¯=1.5m)and
h= effective depth of pit

* Step 6 - The total depth(H) is calculated from effective depth(h) and desired free space(Assumed 0.5m is kept at the top of the pit.

H(m)=h+0.5 (3)

* Step 7 - Simple Pit Latrine: For structural stability reinforcement is placed in the slab (Fig. 2), need steel reinforcement. Prefabricated cement slab of a simple pit latrine prevents transmission of hookworm. Pit lining is required in loose soils.

* Step 8 - Ventilated Improved Pit Latrine(VIP): A VIP latrine has a tall vertical vent pipe which has a fly screen fitted at its top responsible for both odour and fly control. (Fig.3).

Types of VIP latrine are:

Single Pit : It has only pit with own vent pipe and a superstructure over it. Its design year is about ten years.(Fig. 4)

Alternating Twin Pit:

a) It has separate pits(each with their own vent pipe under only one superstructure).
b) The slab within the superstructure has two squat-holes (over each pit) (Fig. 5)

c) Only one squat hole and pit are used at a time.
d) When one pit is full after 1-3 years, its squat-hole is covered up and the next one is put into service. After a further period 1-3 years, when the second is full, the contents of the first pit are removed and used it again. The alternating cycle goes on.
e) This type of latrine is thus a permanent sanitation facility and suitable for using in urban areas where there is insufficient space.

Special features of VIP Latrine:

a) Odour Control: The principle mechanism of ventilation in VIP latrines is the action of the wind blowing across the top of the vent pipe. The wind effectively sucks air out of the vent pipe and this air is replaced from the atmosphere via the latrine superstructure and squat hole. A constant circulation of air from outside the latrine, through the superstructure and squat-hole, and up and out of the vent keeps the latrine odour-free.

b) Insect Control: Female flies, searching for an egg-laying site, are attracted by the faecal odours coming from the vent pipe but they are prevented from entering by the fly screen at the outlet of the vent pipe. Some flies may enter into the pit via the squat-hole and lay their eggs in the pit. When the new adult flies emerge they instinctively fly towards light, However, if the latrine is dark inside the only light they can see is that at the top of the vent pipe. If the vent pipe is provided with a flyscreen at its top, the new flies will not be able to escape and they will eventually fall down and die in the pit.

c) Special Consideration for Designing VIP Latrine:

i. **Design Life:** For single Pit at least 10 years and for the alternating twin pit should be about 1-2 years.

ii. **Dimensions:** Cross-sectional area should be within 2m®Object and avoid large span cover slab. In case of round type pit, one household commonly have a diameter 1-1.5m and in case of square or rectangular type pit, a width of 1-1.5m.

iii. **Materials:** Vent pipes of a wide variety of different materials are used: Polyvinyl chloride(PVC), unplasticized PVC(uPVC), bricks etc. Its durability (Including corrosion resistance), availability, cost and ease of construction.

iv. Length: The vent pipe should be sufficiently long so that the roof does not interfere with the action of wind across the top of the vent pipe. It is at least 500mm higher than the roof.

v. Diameter: The internal diameter of the vent pipe depends on the required venting velocity necessary to achieve the recommended ventilation rate 20 m®Object¯/hr., and it is also depends on the internal surface roughness of the pipe, its length (which determine the friction losses), the head loss through the flyscreen and the wind direction. Some recommendations for the minimum internal size of vent pipes are:

PVC	150mm diameter
Brick	230mm Square
Others	230mm diameter

vi. **Flyscreen:** The purpose of the flyscreen is to prevent the passage of flies and mosquitoes: The mesh aperture must not be larger than 1.2X1.5mm. It should be made of corrosion-resistant material that is able to withstand intense rainfall, excessive temperatures and strong sunlight. Preferable to use stainless steel screens.

vii. Relocation and Emptying of Pits:

a) When single pit VIP latrines become full, there are two options:
1) Construction of new latrine on adjacent site.
2) Emptying the existing pit.

b) A better solution might be to use single-pit VIP latrines with soakaway or alternating twin pit latrine.

c) **Soakaway Design**: The VIP latrine with adjacent of Soakaway increase the pit life. The latrine pit is completely sealed with cement mortar of brick work and a PVC pipe of 75mm dia is attached at a height of about 2.25m above the pit base which leads to the adjacent soakaway.(Fig. 6)

The Soakaway has diameter of 1.5m and a depth of 2m; it is lined with unmortared bricks to a depth of 1.4m At this depth a reinforced concrete cover slab is placed on the bricks and the remaining space above it backfilled.

* Step 8 - Reed Odourless Earth Closet(ROEC): The excreta is deposited into the pit via a chute located at the base of squat hole(Fig. 7). the ROEC is fitted with a vent pipe to control odour and insect nuisance. This type of latrine is commonly used in South Africa. It is similar to Single Pit VIP latrine.

3.2 Pour Flush Latrine Technologies

A further improvement to the pit latrine can be obtained with a water seal. Water seal is a U-pipe filled with water, attached below the squatting pan which completely prevents passage of flies and odours. The water seal is only 15-25mm deep and the latrine can be flushed by hand using 1.5 to 2.0 litres of water. The latrine can also be located, if desired inside the house with off-set pit. Smaller quantity of water used in a pour flush toilet is sufficient to carry the excreta to a soakage pit up to 8m away.

3.2.1 Types of Pour Flush Latrine

There are two types of pour flash latrine:

i. Single pit pour flush latrine
ii. Twin pit pour flush latrine

3.2.1.2 Single pit pour flush latrine

The single pit pour flush latrine comprises of a squatting slab with a water seal and a pit. When the pit fill up a new pit has to be dug and superstructure has to be relocated over the new one or the pit has to be emptied.

Types of single pit pour flush latrine:

a) Direct single pit pour flush latrine: Water seal trap built with its slab and directly placed over a pit.
b) Off-set single pit pour flush latrine: Having siphon as a connector between the water seal and the pit situated at a distance place(Fig. 8)

3.2.1.3 Twin pit pour flush latrine

Twin pit system comprises of i) a squatting pan, ii) two leach pits and iii) a Y-junction for direct excreta from squatting pan to either of the two leach pits(Fig. 9).The pits are used alternatively and at any time only one pit is in use. When the first pit is full, the flow of excreta is directed to the second pit through a Y-junction and the contents of the first pit is left to decompose. The contents of the first pit decomposes to a safe, pathogen free humus within 18 to 24 months. The contents of the first pit then be dug out and the pit is kept ready for reuse. The pit emptying process should be done during dry seasons.

Types of Twin Pit Pour Flush Latrine:

* **Twin pit water seal pour flush latrine**: Its consist of a siphon fitted to the pan which maintains at least a 20mm water seal to prevent the passage of gas and insects from the pits into the latrine (Fig.). The gases generated in the pit normally absorbed by the soil. For ease pass out of excreta with less amount of flushing water, provided a vent pipe on the siphon ahead of the Y-junction

* **Twin pit non-water seal pour flush latrine**: Its consists of a bend fitted to the pan and connected to the pit(Fig.). A vent pipe, exposed to the sun and/or wind which may be installed a stated earlier to induce a current through the pan and up the vent. This will prevent bad smell from pits getting into the toilet. The end of the vent should be covered with a mesh to prevent flies/insects getting into or out of pits.

3.2.2 Design Consideration

* Step 1: The shape of pits may be circular, square, rectangular or even triangular depending upon the morphological condition of the site.
* Step 2: Min. water requirement is 1.5-2.0 litres for flushing the toilet by hand
* Step 3: The pits will be shallow in depth, it should not exceed more than 1.8m (For Bangladesh trends), this type of measured has taken to avoid ground water contamination and for ease emptying.
* Step 4: Pits may be lined with burnt clay, concrete, brick masonry, or even bamboo. About 0.6 m below the top of pit, honeycomb brick with horizontal open brick joints should be provided.
* Step 5: The inlet into the pit should be at least 0.5m above the highest ground water level.
* Step 6: A free space should be kept over the inlet of the pit. In practice it is about 0.5m.
* Step 7: In low lying or flood prone areas, the pits should be constructed on elevated earthen mounds with at least 1.5m earth covering all around the pits.
* Step 8: Bottom of pit should remain undisturbed and unsealed.
* Step 9: Safe distance between pits and water sources should be at least 10.0m.
* Step 10: Permeability of surrounding soil is important for function of the pit latrines. A sand envelope of at least 0.3m should be provided around the pits.
* Step 11: Distance between two pits should be , at least, equal to the effective depth of pits which is measured from the inlet pipe to the bottom of the pit.

3.2.2.1 Design of Pour Flush Latrine

a) The pit volume may be calculated from the following equation (after Kalbermatten,et. al. 1980).

$$\mathbf{V(m^3) = 1.33 \times C((m^3/person/year) \times P\ (person) \times Life(N)\ Years} \quad \mathbf{(3)}$$

Where, V= Effective Volume of Pit (m^3)
C = Sludge accumulation rate, which is about 0.04m®Object¯/person/year
P = Number of person using the latrine, and
N = Number of years the pit is to be used before emptying.

b) Effective depth of the pour flush pit latrine may be calculated from the equation(2):

Total depth = Effective depth of pit +0.5m **(4)**

3.3 Bucket Latrine

The bucket latrine consists of a squatting plate or seat immediately above a bucket of 20-30 litres capacity, into which the faeces and urine fall (Fig.). The bucket can be removed through a small door at the back of the latrine which usually faces onto a road or alleyway. The design of the latrines is usually poor. As a result, they are not easy to wash and keep clean, and have no provision for split liquids to drain away. Generally the latrines smell very badly and are breeding site for insects. Due to inherent health hazards the bucket latrine system is not recommended.

3.4 Vault Systems

The vault toilet system utilises a watertight vault located either offset from or beneath a water seal device for storage of the excreta over a period between two to one month (Fig. 9A). It is suitable for use in densely populated urban areas where on-site sanitation systems cannot be used, where

water borne sewerage is too difficult and expensive to install, and where institutional ability to organise and maintain a collection system exists.

The low-cost of installing affordable vaults, in comparison with water-borne sewerage means that these are affordable sanitation systems, at least in terms of the initial capital costs. The required working or effective volume of the vault is calculated from the formula:

$$V=NQD/K \qquad (5)$$

Where,

V = The working volume in litres
N = The number of users
Q = The average volume of excreta plus flushing water (Litres per person per day)
D = The time between nightsoil collection(days)
K = The vault volume under utilisation factor.

The average nightsoil contribution(Q) is generally less than 10 litres per person per day. The emptying cycle is usually once every 14 - 28 days. The vault volume underutilization factor, K, is introduced since the vault will normally be emptied before it is full. For well maintained and organised collection vehicles K may be as high as 0.85, but often it may have to be as low as 0.5. The vault needs not be large.

Vaults can be emptied manually but this is unhygienic because of the likely spillage and so, wherever possible, the emptying should be done mechanically. The usual type of vehicle is a truck mounted tanker equipped with a vacuum pump.

3.5 Aquaprivy

Aquaprivies are essentially small septic tanks located directly below a squatting plate which has a drop-pipe extending below the liquid level in the tank to form a simple water seal. Figure shows a conventional aquaprivy. To prevent odour, fly and mosquito nuisance in the toilet, this water seal has to be maintained by adding sufficient water per toilet visit to the tank via the drop-pipe to replace any losses. The excreta are deposited directly into the tank where they are decomposed anaerobically in the same manner as septic tank.

The tank volume is usually calculated on the basis of 1.5 litres of excreta per day plus an additional 4.5 litres per day per person for maintenance of the water seal. Thus, the aquaprivy effluent flow is about 6 litres per person per day.

The soakway should be design on this basis, although it is common practice to include a factor safety so that the design flow would be about 8 litres per person per day. The side wall area of the soakway should be calculated assuming an infiltration rate of 10 m^2 /day. As with septic tans, there is an accumulation of sludge (0.03 - 0.04 m^3 /person/year(which should be removed when he tank is 2/3rd full. The resludging processes carried out every 2 -3 years. The liquid depth in the tank is normally 1 to 1.5 metres in house hold units.

3.6 Septic Tanks

A septic tank is rectangular or cylindrical chamber, usually located just below ground level, that receives both excreta and flush water from toilets as well as other household waste water(sullage). As shown in Fig. 10, settleable solids settle to the tank bottom, accumulate, and are the anaerobically digested. A scum of light-weight materials(including fats and greases) rise to the top. The clarified liquid flows through an outlet structure just below the floating scum layer and is normally treated through an outlet structure just below the floating scum layer and is normally treated through a subsurface soil absorption system. The effluent from a septic tank is an

obnoxious liquid, containing high concentrations of organic matter, nutrients, and enteric micro organisms. It should not be discharged without treatment to surface drains, streams or lakes.

3.6.1 Design of Septic Tanks

A septic tank should designed to remove almost all settleable solids and to decompose organic matter anaerobically. To accomplish this, the tank must provide the following:

* Step 1: Proper volume of the septic tank to adequately retain the waste.
* Step 2: Proper placement of inlet and outlet devices and adequate sludge and scum storage space to prevent the discharge of sludge and scum in the effluent.
* Step 3: Since the digestion process is anaerobic, requiring no oxygen, no direct ventilation is necessary. However, provision should be made to permit the escape of the gases produced in the tank, through a ventilation pipe.

3.6.2 Treatment of Septic

There are three general procedures for disposing septic tank effluent.

a) Absorption fields and Evapotranspiration Beds: As shown in Fig. 11, the effluent flows by gravity from the tank through a closed pipe and a distribution box into perforated pipes in trenches. Fig. 12, Shows the detailed construction of a trench. Bacteria and oxygen in soil help purify the effluent. The performance of a soil absorption system depends on the ability of the soil to accept liquid, strain out bacteria, absorb viruses, and filter the wastes. A proper site evaluation requires accurate measurements of the degree of slope, the position of ground water table, the effective soil depth, and depth of any bedrock or other impermeable materials.

The most important characteristics of the disposal field is its soil permeability. A percolation test is recommended to give a measure of soil permeability. The design approach of absorption fields can be calculated according to: $L = \frac{NQ}{2DI}$ (6)

Where, L = Trench length (m)
N = Number of users
Q = Wastewater flow (lit/capita/day)
I = Design infiltration rate (lit/m^2 /day)(Assumed 10 l/ m^2 /day

b) Evapotranspiration Mounds: In areas where the WT is near the surface or soil percolation is insufficient, an evapotranspiration mound or bed may be substituted for a drainfield. These should be located in areas not subject to flooding and on a sloping grade to facilitate gravity drainage of the system. Design criteria for these mounds depend on climate, soil type, and vegetation. Pilot studies are required to confirm the suggested dimensions (Fig. 13)

c) Soakage Pits or Soakways: Soakwayspits or soakways (Fig. 14)are recommended as alternatives when absorption trenches are impractical. Typically, soakways are 2 to 3 metres in diameter, and 3 to 6 metres deep. The depth and diameter of a pit are determined using an infiltration rate of 10 litres per square meter per day or when determining infiltration capacity of the pit, the bottom area of an absorption pit normally becomes clogged in a short period of operation, and only its side wall areas remain effective in waste water infiltration.

3.6.3 Small Bore Sewerage

Due to a variety of factors on-site sanitation systems often cannot be used, particularly in densely populated urban areas. Waterborne sewer systems are very suitable for serving these areas because they are able to dispose of both excreta and household wastewater or sullage with an absolute minimum of health risk to the users.

In many tropical countries conventional sewer systems based on those used in the industrialised countries have been constructed. These systems have proved so expensive that many households cannot afford to pay the sewerage charges and often only a small proportion of premises have been connected to the systems, even after they have been in operation for many years.

Small-bore sewerage is a sanitation technology which has all the advantages of water-borne sewerage for the user, but these systems cost far less to construct than conventional ones.

There are three basic components to a small-bore sewer system (Fig. 15)

a) House Connections: Which collect all the household wastewater(excreta, washing water, etc)
b) Interceptor tanks: which remove both the suspended and floating solids from the wastewater,
c) The small-bore sewer network; which consists of small diameter pipes collecting the settled waste waters and discharging them into an existing sewerage system or treatment plant.

3.6.3.1 Special Considerations

The usefulness of the above technology to developing countries in the following :

a) Convenience : Convenient to use
b) Water requirements : Since the sewers are not required to carry solids.
c) Excavation Costs : The sewers do not need to be designed to maintain a min. flow velocity for self-cleansing.
d) Materials Costs : Minimum
e) Operating costs : Routine maintenance is limited
f) Treatment requirements: simple
g) Upgrading costs : Small-bore sewer system are very suitable for upgrading from existing sanitation services
h) New technology : Its a new technology

4.0 Present Practice in Bangladesh

Present practice of our country is given below:

* To line the pit with five concrete rings having inside and outside diameters of about 2.25ft and 2.6ft respectively and about 1.0 ft height.
* The slab used is either made of ferro-cement or reinforced concrete.
* The water seal of the pan is also made of ferro-cement. Now a days, very cheap and durable plastic pans with water seal are also available. A low-cost slab + one ring option might be adopted for stable soil condition.
* Single pit pour flush latrines are promoted by UNICEF, DPHE, some and NGOs.

5.0 Possibility of Sanitation Technology

The advantages and disadvantages of various sanitation technologies are briefly described as follows:

Technology	Advantages	Disadvantages
Simple Pit Latrine	* least costly * structurally safer * easy construction & maintenance * free from any kind of major risk * prevents hookworm transmission	* flies lay their eggs in poorly built latrines. Increases in the population of flies helps in spreading of diseases caused from faecal pathogens carried by flies.

Technology	Advantages	Disadvantages
VIP Latrine	* low cost * easy construction & maintenance * min. water requirement * min. health risk * controls odour and insect	* lack of space for relocating the pit in densely populated areas * potential for groundwater pollution * difficult to construct in rocky & high water table area.
Reed Odourless Earth Closet (ROEC)	* pit is larger, so than the longer life than the VIP * pit can easily emptied without disturbing the superstructure and it can be a permanent facility * it is not possible to see the excreta in the pit, which encourage the use of the latrine	* the chute of ROEC can be easily fouled with excreta providing a site insect and odour nuisance * the chute has to be regularly cleaned with a long handled brush
Single Pit and Twin Pit Pour Flush Latrine	* less expensive compared to conventional latrines(with sewerage systems) * offers long term, appropriate, and hygienic solution for excreta disposal * requires less amount of water (1-3.0lit/flush) * can be upgraded to connect to a sewer system or septic system * eliminates odours, insect and fly breeding * safe from any risk * can be located, if desired, inside the house * potential for resource recovery using the sludge as soil conditioner * easy construction & maintenance	* twin pit latrine can serve as a permanent structure because of its pits are used alternately * requires separate sullage disposal facilities * water(at least 4.0 lit/person/day) must be available throughout the year * water seal may clog easily if garbage is thrown into it * risk of polluting nearly water sources * difficult in construction & maintenance of twin pit pour flush latrine * areas with extended water table, shallow soil overlying hard rock / impermeable soil, construction is more difficult and expensive
Aquaprivy	* no danger of clogging by bulky anal cleansing materials; * possible location inside the house * low odour and insect problems * minimal risks to health * low annual costs * potential for upgrading * sullage disposal potential	* the water seal is often broken. * small but significant amounts of water are required. * It is expensive sanitation option. * skill is necessary to construct this tank. *

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10 Solid Waste Management

1.0 Importance of Solid Waste Management

In early times, the disposal of human and other wastes did not carriage a significant problem, for the population was small and the amount of land available for inhalation of wastes was large. In recent research we speak of recycling the energy and fertilizer values of solid wastes. In many of the developing nations where farmers recycle solid wastes for fuel or fertilizer values. The practice of throwing wastes into the paved or unpaved streets, roadways, and vacant land - led to producing offspring of rats & insects, carrying the germs of disease, and the outburst of plague (some where in West Bengal). The lack of proper plan for the management of solid wastes led to the many subsequent epidemic and high death tolls. The relationship between human health and the improper storage, collection, and disposal of solid wastes is quite clear. Ecological impacts, such as water, air and soil pollution, also have been attributed to improper management of solid wastes. Liquid from dumps and landfills has contaminated surface and ground water. In industrial areas the liquid leached from waste dumps may contain toxic elements, such as copper, arsenic, and uranium, or may contaminate water supplies with unwanted salts of calcium and magnesium.

Modern technological advances in the packaging of goods create a invariably changing parameters for the designer of solid waste facilities. Concerning particular significance are the increasing use of plastics and the use of frozen foods, which reduce the quantities of food wastes in the home but increase the quantities in agricultural processing plants. The engineers responsible for the design of solid wastes facilities must be aware of trends, even though they cannot be penetrating in the prediction of changes in technology that will affect the characteristics of solid waste.

On the other hand, almost everyone is familiar with solid wastes, especially those generated in municipalities, such as food wastes and rubbish, abandoned vehicles, destruction and construction wastes, street sweepings, and garden wastes. Roughly, we can identified the solid wastes generated in each year from industry as industrial wastes, agriculture as agricultural wastes, from mines and mineral as mineral wastes, and from human & animal wastes. Solid wastes collected from urban sources as combined residential and commercial, industrial, institutional, demolition and construction, street and alley cleanings, tree and landscaping, park and beach, catch basin and sewage treatment plant solids. Components of solid wastes generated in municipal area are paper, glass, metal(Ferrous, Aluminium and other non-ferrous), plastic, rubber and leather, textiles, wood, food and miscellaneous inorganic.
The main objective of this study is to find out the importance of solid waste management following the appropriate methodology. Also to provide a general introduction to the field of solid waste management.

1.1 Definition

Solid waste management may be defined as that discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes in a manner that is in accord with the best principle of the public health, economics, engineering, conservation, aesthetics, and other environmental considerations, and that also is responsive to public attitudes.

Solid waste management includes all administrative, financial, legal, planning, and engineering functions involved in the whole spectrum of solutions to problems of solid wastes thrust upon the community by its inhabitants. The solutions may involve complex interdisciplinary relationships

as political science, geography, city and regional planning , economics, public health, sociology, demography, communications, and conservation, as well as engineering and materials science.

Solid waste is a common phenomena of waste production by the biological community is a natural process whereas waste generated from the abiotic component, particularly from the non-renewable & non biodegradable components of nature created hazards in the environment. Environmental technologist, ecologist all around the world are unanimously considering the harmful effects of the waste materials on natural ecosystems & are trying to improve clean technology for the safety of environment.

1.2 Functional Elements

The management of solid wastes now a days are very complex due to the -

a) Quantity and diverse nature of solid wastes.
b) The development of sprawling urban areas.
c) The funding limitations for public services in large cities.
d) The impacts of technology
e) The emerging limitations in both energy and raw material.

As a consequence if solid waste management is to be accomplished in an efficient and orderly manner, the fundamental aspects and relationships involved must be identified and understood clearly. The activities associated with the management of solid waste from the point of generation are depicted in Fig. 1.1

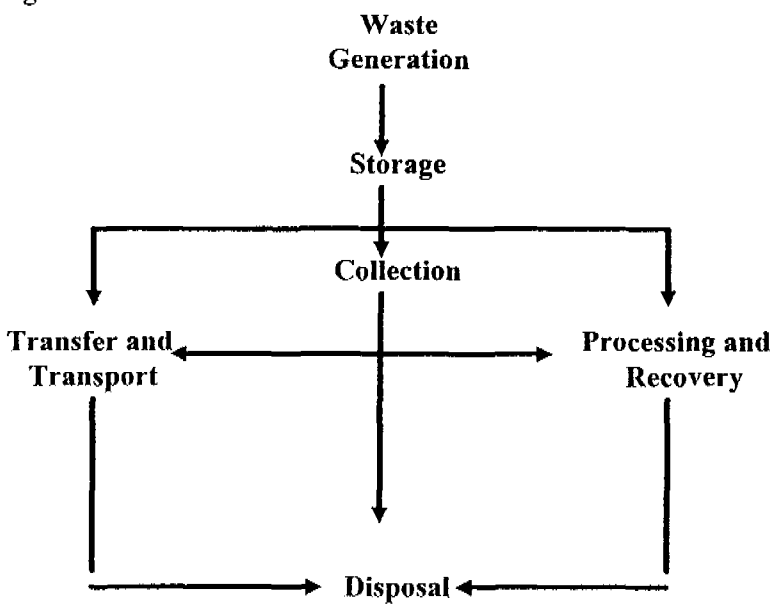


Fig. 1.1

1.2 Generation of Solid Wastes

Solid wastes, include all solid or semisolid materials that the possessor no longer considers of sufficient value to retain.

1.2.1 Sources and Types of Solid Wastes

Knowledge of the sources and types of solid wastes, along with data on the composition and rates of generation, is basic to the design and operation of functional elements. Sources of solid wastes are related to land use and zoning.

a) Residential, b) Commercial, c) Municipal, d) Industrial,

e) Open areas, f) Treatment plants and g) Agricultural

Table 1.1 Typical Solid Wastes Generating Facilities, Activities, and Locations associated with source Classification

Sources	Typical Facilities, Activities or located where wastes are generated	Types of solid wastes
Residential	Single-family & multi-family dwelling	Food wastes, rubbish, ashes
Commercial	Stores, restaurants, markets, office building, hotels, motels, print shop, repair shop, medical and institutions	Food, rubbish, ashes, demolition and construction wastes, hazardous wastes
Municipal	Same as above	Same as above
Industrial	Construction, fabrication, light and heavy manufacturing, refineries, chemical plants, lumbering, mining, power plants, demolition, etc.	Food, rubbish, ashes, demolition and construction wastes, hazardous wastes
Open Areas	Streets, alleys, parks, vacant lots, playgrounds, beaches, highways, recreational areas, etc.	Special wastes, rubbish
Treatment Plant sites	Water, waste water, and industrial treatment process, etc.	Treatment plants wastes, composed of residual sludge's
Agricultural	Field & row crops, orchards, vineyards, dairies, feedlots, farms, etc.	Spoiled food wastes, agricultural wastes, rubbish, hazardous wastes

1.2.2 Moisture Contents with Solid Wastes

Table -1.2 Typical Data On Moisture Content of Municipal Solid Wastes Components.

Component	Range	Typical Value(%)
Food Wastes	50-80	70
Paper	4-10	6
cardboard	4-8	5
Plastics	1-4	2
Textiles	6-15	10
Rubber	1-4	2
Leather	8-12	10
Garden trimmings	30-80	60
Wood	15-40	20
Glass	1-4	2
Tins Cans	2-4	3
Non-Ferrous Metals	2-4	2
Ferrous Metals	2-6	3
Municipal solid wastes	15-40	20

2.0 Technology in use for Waste Management:

Sanitation: At present about 44% of the rural population uses sanitary latrines in our country. People are now latrine conscious with 61% using some form of latrine. Overall urban sanitation coverage has risen from 20% to 42%.

Low affordability and limited capacity of the public sector to deliver sanitation services, have led to the adoption of the slab-plus one ring option and promotion of the home made latrines.

Solid waste management especially primary collection is predominantly a labour oriented operation in the country. Types of wastes are domestic wastes containing vegetable materials (80-90%) ; inert materials (4-6%), paper and card boards (2 -10%) , textiles (1- 2%) and glass, metals, plastic, strew, bone wastes, street and commercial wastes containing soil, fifth, papers, building materials, hotel and restaurant wastes etc. They pose a health hazard as pathogens thrive on them. Industrial wastes containing refuses from tanneries , pharmaceuticals, ceramics, dyes and varnishes, textile industries, pesticides, heavy metals etc. They are a major source of pollution, threat to public and ecological and environmental degradation. Clinical wastes include all waste from hospitals, clinics. Removed in some cases by plastic bags.
No other scientific method is practised. They are threat to public health. In residential areas, individual community contains, local bans at kerbside are used for collection. The wastes are transported by trucks, hand cards etc. Transportation is erratic, irregular and reported to be 3 times a week.

Wastes from markets, commercial areas and streets are collected by hand carts and transferred to bins and transported by trucks. Trucks directly collect from the storage bins and transport to designed disposal site and ditches, low-lying areas and road sides. Demountable container trucks are in use in metropolitan cites.

No sorting is done at collection site. Rag pickers sort out their need. Animals and birds scatter, refuses for their need.

3.0 Short description about " Privatisation and solid wastes in Municipality and Municipalities:"

The Municipalities are aged old local self-government institutes rendering municipal services in sanitation and health, waste management. But ever increasing migration of rural population to urban areas coupled with inadequate resources in men and material have rendered them in efficient conventional arrangements are not enough and there is urgent need for alternative strategies to cope with the situation.

Municipal service is essentially a people oriented function. Community participation is a necessity for a sustained system. NGOs have been doing a good job with the support and co-operation of the communities in their development efforts. With this in mind , LGED decided to undertake an experiment with the help of a public private partnership with an NGO in Mymenshing , Kushtia and Sylhet.

It was agreed that the necessary manpower from existing staff and materials from the municipalities would be used by the NGO on the payment. A 20% to 25% reduction was achieved during two year operations (1995 & 1996) in 3 municipalities from the allocated amount in the budget . More importantly, there was marked improvement in the services and residents found the drains flowing , wastes taken away and environmentally clean healthy town. The beneficiaries revealed positive reactions about the work. They praised for the cleanliness as there was no foul odour around the bins areas.

For solid waste disposal , dustbins were constructed by the project. One masonry dustbin was allocated per 100 families at a cost of Tk. 1800. SIP also provided one CI dustbins for 20 families at a cost of Tk. 930/- where the users contributed Tk. 2 each . One pushcart was provided to carry

garbage from the CI bins to the masonry bin. Garbage from homes are carried to the CI bins mainly by women and children.

Solid waste management are the most ignored and least studies areas in the environmental sanitation of Sylhet in Bangladesh. Most of the benefits of WSS services are lost when poor and inadequate solid waste collection contribute to an unhealthy environment. So, Sylhet Municipality should take care of this sector.

Traditionally , SWM is seen as municipal functions with no community involvement. Lack of general awareness among people regarding the benefits of clean drains and proper disposal of solid wastes have resulted in the total absence of community initiatives. It is the responsibility of corresponding engineer to increase awareness among people through field workers worked under him.

4.0 Case Study; Solid Waste Management(Dhaka City):

4.1 Generation of solid waste in Dhaka City:

The solid wastes in Dhaka City are generated in Dhaka City from domestic, trade, industrial and commercial sources. The waste comprises of dust, food wastes, packing materials, paper , metals , plastic, broken glass, discarded clothing etc. Both degradable and non-degradable waste are thrown into same waste bins or waste accumulation centre.

According to DCC, solid waste generated per day is estimated between 2000 to 3000 tons. Usually 2000 to 2500 tons of wastes are generated daily during dry season and 2500 to 3000 ton of garbage per day during rainy season. DCC collected solid waste remain between 1000 to 1500 tons per day. so huge amount of reusable parts of garbage are usually collected by scavengers, reducing the quantity of waste for collection and disposal.

According to World Bank funded study of solid waste collection,

- density of household waste is about 225 kg/ m
- waste removed from the collection bins has a density of 275 kg/m

DCC currently collecting an average of 2200 m of garbage per day.

4.2 Management

There are five main aspects of solid waste management in Dhaka City. They are

a. Street sweeping and drain cleaning.
b. Collection
c. Transportation
d. Disposal
e. Recycling.

4.2.1 Street sweeping and Drain Cleaning

The house owners, shoppers of the city area throw refuse on the nearest dustbins in selected place. Scavengers of Cooperation sweep the roads and clean the drains daily in the morning and accumulated the wastes on the side of the drains. They have specific allotted roads and drains which they are to clean.

4.2.2 Collection

Scavengers engaged by corporation collect the street sweepings, drain refuse, accumulated by them earlier and refuse dropped by house owners' shopkeepers and other installations in the nearest collection point or dustbins provided by the city corporation.

Dhaka city corporation provide two types of dustbins on the roads for collection of waste. One type is mottle dustbin made of corrugated sheet, other is fixed pucca concrete bin. Scavengers use cane basket and hand carts for collection of wastes. Generally hand carts are used for collection of wastes at a distant places and narrow lanes and bye lanes where vehicles can not play.

4.2.2.1 Design of Residential Collection System

Design a solid waste collection system to service a residential area with N number of single family dwellings. Assume that a two person collection crew will be used and that the following data are applicable.

a) Average number of residents per service = 3.5
b) Solid waste generation rate per capita = 1.0 kg/capita/day
c) Density of solid wastes(at containers) = 100 kg/cu.m
d)Containers per service = two 16 litres containers
e) Type of service = 50% rear of house, 50% alley
f) Collection frequency = once per week
g) Collection vehicle = rear loaded compactor, compaction ratio= 2
h) Round trip haul distance = 24 Km
i) Length of Work day = 8h
j) Trips per day = 2
k) Off-route factor = 0.15
l) Constants for estimating haul time; = a=0.016h/trip and b=0.029km/h
m) Assume ar site time per trip = 0.1h/trip
n) Following equation can be used to estimate the pickup time per pickup location :

$$t_p = 0.72 + 0.18(C_n) + 0.014(PRH) \quad (1)$$

Where, t_p = average pickup time per pickup location, collector-min/location.

C_n = average number of containers at each pickup location.=2

PRH= rear-of-house pickup locations, percent.=50%

Solutions: 1. Determine the time available for the pickup operation

$$H = N_a (P_{scs} + s + a + bx)/(1-w) \quad (2)$$

Where, H= length of workday, hr/day

N_a =Number collection trips per day, trips/day

P_{scs} = pick up time per trip for stationary container system, hr/trip

s = at site time per trip, hr/trip

a = empirical constant, hr/trip

b = empirical constant, hr/km

x = round trip haul distance, km/trip=24km/trip

w = off-route factor, expressed as a fraction.=0.15

$$P_{scs} = (1-w)H/N_a - (s + a + bx) \quad (3)$$

2. Determine the pickup time required per pickup location using assumption no. 14
3. Determine the number of pickup locations from which wastes can be collected using-

$$N_p = 60 P_{scs} n / t_p \quad (4)$$

Where, N_p =number of pickup locations/trip

n = number of collectors

4. Determine the vol. Of wastes generated per pickup location per week

Vol. Per week = (1.0 kg/person/day)(3.5 persons/pickup)

5. Determine the required vol. Using

$$v = V_p N_p / r \quad (5)$$

Where, v = vol.of collection vehicle, km^3 /trip

V_p = vol. Of solid wastes collected per pickup location, km^3 /trip

N_p = number of pickup locations per trip, locations/trip

r = compaction ratio

6. Determine the number of trips require per week using

$$N_w = T_p F / N_p \quad (6)$$

N_w =number of collection trips per week, trips/week

T_p =total number of pickup locations

F = collection frequency per week, times/wk

7. Determine the time requirements using

$$D_w = [(N_w) P_{scs} + t_w (s + a + bx)] / [(1-w)H] \quad (7)$$

D_w = time required per week days/wk

4.2.3 Transportation

In Dhaka City corporation area there are different capacity covered vehicles to carry city wastes from collection points to final place.

Table 2.1 Transportation process (DCC report 1990)

Type	Capacity (tons)	Quantity
1. Mitsubishi	5	62
2. Bedford	5	10
3. Mitsubishi	3	9
4. Isuzu	3	20
5. Isuzu	2	48
6. Mitsubishi	1.5	41

Out of 190 trucks, the city council is maintaining an average 100 collection vehicles per day due to technical problem and non availability of spare parts. A majority of trucks have a closed body with open flies on the back and 3-4 vertically sliding shatter on each sides. Each truck has an assigned area and makes mores than on trip to the landfill area per day.

The trucks collect the generated in the Dhaka City and transport to the final disposal site in two shifts. day shift starts from 5 Am. to 2 p.m. . , whereas the night shift is from 8.30 PM to 2 p.m. Moreover some special trips are provided on VIP roads from 1 am to 8 PM. On an average 360 trips are made everyday by vehicles of different capacity. Some time trip increases due to seasonal variation.

The waste collection, street cleaning and drain washing are carried out by DCC employed sweepers. DCC employs about 4200 cleaners, augmented by another 300 in monsoon. These are 88 conservancy Inspector and 200 supervising inspector look after the work of cleaners. These are only 1.2 workers per thousand people for solid waste management in Dhaka City.

4.2.4 Disposal

Solid wastes are disposed by landfilling. Crude dumping methods are used in Dhaka though every crude dumping is an environmental disaster causing health risk from flies, rats, air pollution and water pollution through leaching by rainfall. Since open dumping is most economical, its practice by DCC.

DCC now dump solid wastes as landfill at Jatrabari, which is a 50 acre area and was about 100ft lower than road level. Before this site is brought under operation, a 20 acre area at Mirpur was use for this purpose. It was taken about 3 years to fill that land.

Land filling operation are carried out in an uncontrolled and unsanitary manner. Solid waste is unloaded by uncovered hand along the road side, which is then pushed inside by bulldozers. The garbage is not covered by soil, resulting a wide spreading of partially decomposed waste. Poor people engage themselves in collecting residual recyclable.

4.2.5 Recycling

The constituents which are commonly extracted from domestic trade wastes for industrial use are-

Table 4.1 Recycling Process

Source of Components	Recycling
Paper	For repulping
Plastic	for production in inferior grade
Metals	for smelting
Glass	for remelting
Textiles	for paper makings, machinery wipers etc.
Rubber	for down graded use.
Coal, coconut shells	use as fuel due to poverty
Cans	domestic vessels
Vegetable wastes	for animal feed

Several times more people are engaged in collecting and processing these waste for industrial use, according to a survey reports.

4.2.6 Problems arising from non-collecting of solid wastes

The following problems may be identified as arising from the non- collection of solid wastes:

i) Waste dumped in streets favours the development of infectious diseases such as dysentry, worms, enteritis, typhoid fever, hepatitis, and cholera.
ii) Children and domestic animals often play on the waste, thus making direct contact with contaminated matter.
iii) Waste eventually creates dust in the streets, which in turn may cause lung infections.
iv) Waste in the origin of pungent odours, particularly during the summer.
v) The appearance of the town is unsightly.
vi) Rain will take waste to sewers, if any, causing them to be blocked.
vii) During sweeping or shovelling of wastes there will be a dust cloud which may be hazardous to the health of the sweepers.

4.2.7 Effect on Workers

In the present system the workers come in contact with dust at a number of points thus exposing him to infection. Since Dhaka city is not completely sewered and due to a huge number of slum and floating population, night soil is often deposited with refuse and come in contact with the workers. Though hospitals are expected to provide incinerators for their wastes, it often reaches municipal dustbins. Thus workers are exposed to infection at a number of points.

The results of stool samples of a group of refuse worker indicates that most of the refuse workers suffer from at least some parasitic infection.

Those who are engaged in refuse collection, many of them suffer from skin disease. Some of them suffer from diarrhoeal diseases, viral hepatitis, plastic waste contain toluene isocyanide and cadmium type poisonous substances which causes bronchial asthma, chronic bronchitis.

Those who work in the recycling factory also suffer from different types of diseases. Working procedure sometimes so dangerous that labourers working in the factory suffer from respiratory problem. Workers in the plastic factory works wear the hot burner, spreading dust of silica and plastic which hazardous for their health.

4.2.8 Separation of Materials

The key successful recycling of material contained refuse lies in the separation of valuable components from main bulk of the waste. Types of separation:

a) Mechanical Separation.
b) Hand Separation

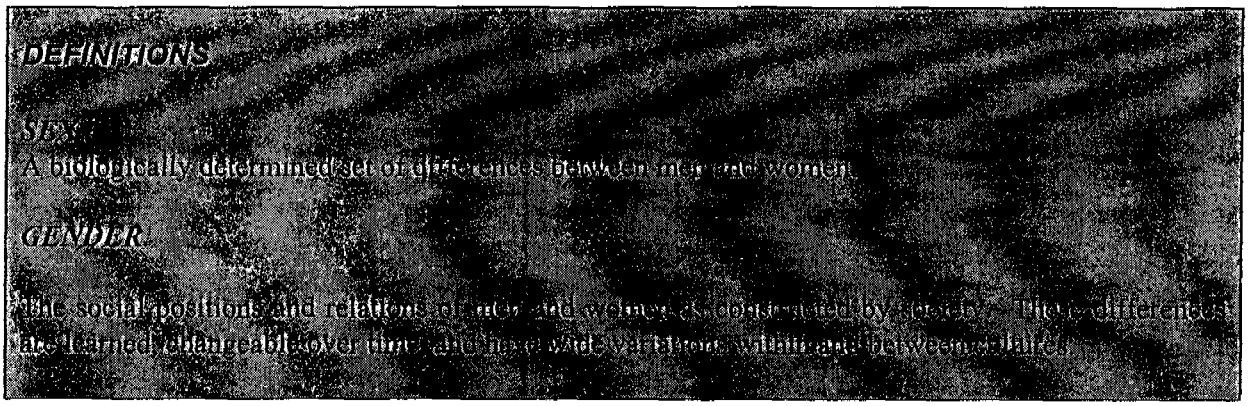
5.0 Recommendation

Municipal can take similar project on solid waste management and to utilise of land fill gas with different organisations.

In Bangladesh development scenario, an engineer is a key man in the whole process. They are the technical experts. Without them , development is only a slogan. The task id theirs. On such a demanding situation, without going into details, the role of engineers to be effective , if they considered following aspects very carefully.

1. Technology should serve local needs and aspirations.
2. Local innovations should be encouraged and used.

12 Gender Aspects in WSS



WOMEN'S ROLES IN THE WATER AND SANITATION SECTOR

Women have traditionally played a central role in the field of water and sanitation. Hence, they are important actors and a mainstream interest group within the sector. Without their active involvement and participation Water and Sanitation Project (hereafter referred to as the Project) risk being inappropriate and failing. This paper aims to provide Project staff with some initial tools for planning for a gender sensitive implementation. It should be seen as a "document in process" that is to say that continually evolving. Practical experience gained and lessons learned in the cause of implementation shall hopefully modify and change the content.

Women- to a lesser degree with the assistance from children- are most often the users, providers, collectors and managers of water in the households. They are usually the guardians of household hygiene. Consequently, they may have a great deal of knowledge about water sources, their quality and reliability, restrictions and advantages of their use, acceptable storage methods, etc.

Women also have the main responsibility for disposing of household waste, maintaining sanitation facilities and educating and training children in hygiene. Women and children are likely to be the most frequent users of the new or improved water systems, and women may well be the main disseminators of the new hygiene practices.

GENDER POLICIES

Ideas and practices concerning gender differences and gender relations are usually deeply embedded in the cultural and social structures of any society. Bangladesh is no exception.

However, this does not imply that these ideas and practices cannot be changed. If the Project implementation is to be successful, it is of crucial importance that the women, men and children are involved in local planning and implantation, sharing work and responsibilities. Women, in a number of respects a subordinate group, can easily be denied an active role. If serious gender inequality exist positive discrimination of women may be necessary. Consequently, it is important that the Project includes some specific policies for supporting women and overcoming possible disadvantages.

One type of specific policy addresses the practical gender needs of women and are related to the conditions of women in society. In this context the Project will aim at improving women's conditions through provision of safe water and quality and quality sanitary facilities within easy access.

Another type of policy addresses the strategic gender needs of women and are related to their position in society; their access to resources and decision making. When addressing these needs the Project aim to strengthen women's position in the local community by increasing their capacity to participate in planning, decision making and general implementation of activities. The Project must support the empowerment of women by encourage them to take part in all activities. Gender equality in decision making can lead to more shared responsibilities between men and women in implementation.

Increased access to safe water, sanitation facilities, information, knowledge and training for women results in increased ability not only to take decisions about their own lives but also to contribute to the development of the community as a whole. It is crucial that the male members of the communities understand the reasons and see the necessity for women's involvement in activities. It is essential that men become aware and recognize how women's empowerment can contribute to the development of the community.

A GENDER AWARE PROJECT POLICY

Gender specific questions shall not have a separate status but must be systematically integrated into the general Project planning, implementation and monitoring.

Project staff:

- must ensure that gender considerations are incorporated from the beginning. If the users views are not included from the beginning they are likely to be excluded at later stages as well;
- must take into consideration the differences in the needs and proprieties of men and women;
- shall encourage and support women as well as men to take part in local planning and decision making; training and skill development; taking up leadership and management roles;
- must ensure that implementation and planning is carried out in such a way that both men and women can benefit;
- must address possible constraints to women's participation and seek ways to overcome these; and
- shall ensure that the selected NGOs have adequate female personnel at all levels so that women can be reached directly and that gender issues can be addressed appropriately.

GENDER CONSIDERATION IN PROJCT IMPLEMENTATION

1. The Project shall aim to contribute towards enhancing or fulfilling men's and women's practical and strategic gender needs.
2. Gender specific considerations must be reflected in the Project's Plan of Operation (PLOP), and in the Plan of Actions (PLACs) for the different sub-projects and individual work plans.
3. Progress shall be monitored and evaluated on a gender specific basis.
4. Implementation methods must be adjusted in accordance with monitoring results regarding gender aspects.
5. All Project and NGO staff, whether concerned with hardware or with software, should possess competence and knowledge on gender analysis, including the ability to translate gender-understanding into practical development initiatives.
6. Staff should undergo gender sensitization and training programmes on reasons and practicalities of women's involvement.

THE USERS' ACTIVE PARTICIPATION IMPROVES PROJECT PERFORMANCE

A study on Water and Sanitation Projects, conducted by the World Bank, concluded that gender is not only an issue of equity but also of efficiency. Experience from other projects shows that if women and men actively participate in planning and implementation this will enhance efficiency. Facilities will function better, usage will be more hygienic, recovery of loans will be higher and sustainability in general will be ensured.

HOW TO SUPPORT WOMEN'S PARTICIPATION

Identify barriers and constraints :

- Are women overburden by work?
- Do women have access to information? Are they aware of the Project? Do they need a separate Project Briefing meeting?
- It might be necessary to approach the male leaders and explain why the participation of women is important as tradition may otherwise inhibit women from taking part.

Always ensure that both men and women are approached

- To separately interview or discuss matters with men and women might permit freer discussions.
- Female staff are likely to obtain better access and more accurate information from women than would male staff.

Make it easier for women to attend meetings

- In joint meetings, try to facilitate seating arrangements so that all participants feel comfortable.
- Facilitation of speaking out- are separate meetings necessary?
- Are the community members aware of the meeting and have they received invitations to attend?
- Time and place of meetings should be convenient for both men and women.

Include women in local planning and decision making

- Involvement of women in choice of caretakers and mechanics
- Involvement of women in selection of members to Ward Level WATSAN Committees and different user groups.
- Ensure female representation in the Pourashava and Ward level WATSAN Committees and different user groups.

Expansion of women's traditional tasks

- Operation & maintenance of new facilities.
- Imparting health and hygiene education.
- Collecting and managing funds.
- Taking part in construction of latrines and sinking of HTW.

AVOID A BLUEPRINT APPROACH

A blueprint approach assumes that conditions are known, predictable and controllable. A sound water and sanitation project requires a demand-based, participatory approach that continuously assess what the users want and are able to or willing to pay for new facilitates, their active participation in implementation and decision making. It is essential to consider both men's and women's roles and interests when determining also increases the chances of the acceptance, proper use and maintenance of the new facilities and sustainability and the final impact of the Project. If achievement depends on getting local women men involved in decision making this implies that one has to accept a certain level of unpredictability.

GENDER ANALYSIS AND APPROACH

Gender analysis at its simplest is asking questions about the differences between men's and women's activities, roles and resources to identify their needs. Assessing these differences makes it possible to determine men's and women's constraints and opportunities within the water and sanitation section. Analysis can help to ensure adequate provision of services that men and women want and that are also appropriate to their circumstances. This is a process and will begin with the however, the process is continuous and data collected during monitoring for example should be used to modify and if needed changing direction.

An underlying assumption of the gender approach is that the community-women and men- are the agents of their own development, with the Project in a supportive role. A gender approach means that attitudes, roles and responsibilities of men and women are taken into account, that it is recognized that both sexes do not necessarily have the same access to resources and that work, benefits and impacts may be different for different groups. When identifying needs and priorities of men and women, the gender specific data collected on health, environmental and socio-economic aspects and living conditions during the Socio-Economic Baseline Survey will be invaluable. For example, the health conditions of women may be very different from the health conditions of men. The same is true for the access to resources and the impact of the Project on women and men.

Some reasons for why a gender-specific analysis is relevant:

1. Gender analysis helps to predict how different users will be affected by the Project activities.

2. The information obtained by gender analysis can help in anticipating if the Project will be as efficient, effective or equitable as possible.

3. Experience shows that project and programme planning which does not take into account gender-specific differences in a society is likely to fail or be less efficient as it tends to reach only male members of the community.

4. Poverty alleviation is the main objective of development programme where majority of the poor are women.

5. Women in Bangladesh are the primary agents in managing natural resources such as water etc. and thus pivotal to the development strategies for protecting the environmental and ensuring *sustainable* development.

When formulating gender-specific strategies, the need for a gender approach cannot be over emphasized. A gender approach also seeks to prevent further overburdening of women and stress the importance of not automatically reinforcing and perpetuating traditional roles. It wants to increase women's decision making capacities, empower them and achieve a more equal and just situation with reference to their workload. This implies that the needs and priorities of *men* also have to be addressed, since they are required to change their attitudes and behaviours to support women's participation.

VIEWS AND PREFERENCES ON HARDWARE

Seeking the users views about technology choices and design features helps when considering designs. Men and women often have different views and interests. If this is not taken into account it is likely that the systems will not be used properly. Designs may be technically sound might not be very practical for the women who shall use them. It is of crucial importance to listen to women's views about siting, safety and reliability; convenience; and time and energy demands of various hardware options.

Men's and women's preferences therefore affect not only their responses to the Project but also subsequent acceptance, use and maintenance of facilities.

TRADITIONAL AND NON-TRADITIONAL ROLES

- Avoid placing extra work and/or financial burdens on the target group- if they are involved in decision making the possibility that this will happen decreases.

- Attempt to increase women's authority in management decisions in order to enhance their benefits.

- Traditionally women's involvement in water and sanitation projects has only been in health and hygiene education. Design of health education schemes must also focus on the need for men to support and adopt improved hygiene practices.

During the first stage of Project implementation, when decisions are made on the designs and siting of the new facilities, women as the main users must be consulted on the different options and on additional provision which may be required for washing, bathing etc. Project staff must share with women and men the information available on the technical, financial, managerial, health and workload implications of the various options.

13 Sullage and Storm Water Management

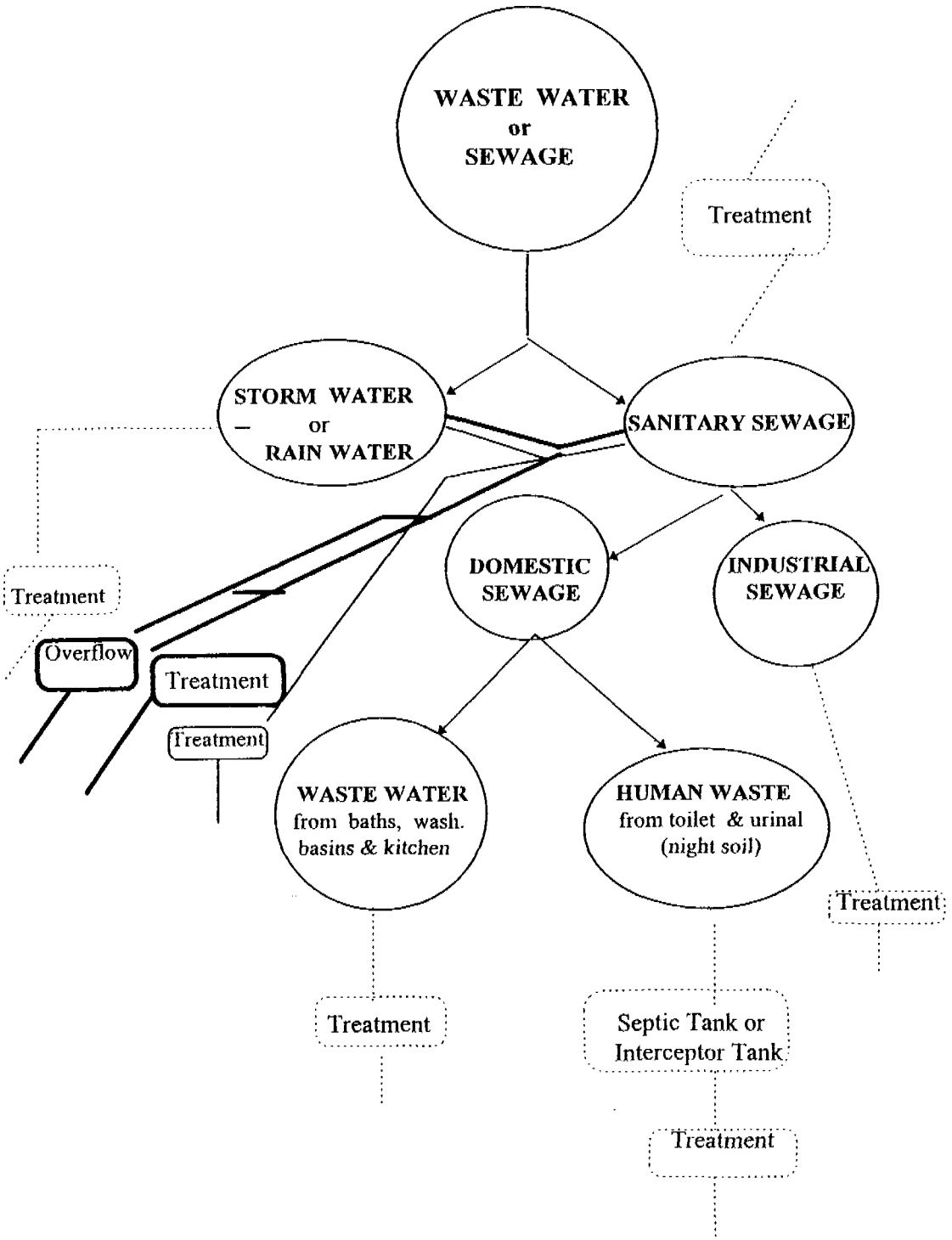


Fig. Sewerage System at a Glance

BASIC DEFINITIONS

SEWER: A pipe or conduit , generally closed but flowing normally not full which carries sewage.

TYPES OF SEWER

Two types of sewer:
(a) Separate Sewer which are classified into Sanitary or Foul Sewer and Storm Sewer
(b) Combined Sewer.

FOUL or SANITARY SEWER: A sewer which carries foul runoff or sanitary sewage (domestic or industrial) to waste water treatment plant and excludes (so far possible) storm sewage & surface runoff (rain water).

STORM SEWER: A sewer which carries storm sewage including surface runoff and street wash water.

COMBINED SEWER: A single large size sewer or conduit which is designed to carry both of the foul runoff (domestic sewage & industrial waste) and surface runoff (storm water).

** In dry weather, the foul sewage is transported to treatment plant and is treated. In wet weather, the surface runoff from the catchment area also enters the sewer and the runoff mixes with the foul effluents to form combined sewage. In some instances, the capacity of the collection system and of the treatment plant is exceeded and the excess flows are diverted from the combined sewer into water courses, termed as receiving waters via combined sewer overflow (CSO).

SEWER SYSTEM:

Three types of system as follows:

(a) **Gravity System**:

- Collect both foul runoff & storm water in one conduit (combined sewer) or in separate pipes (separate system).
- The sewage water/rain water moves under gravity at a fixed hydraulic gradient which is sufficient to create self-cleansing velocities for the transportation of sewage sediment. Self cleansing velocity are 0.6 0.7 m/sec for flowing full or half full.
- Manholes are provided at regular intervals for the cleansing velocity of the sewer.

(b) **Pressure Type System**:

- Collects sanitary sewage or foul runoff only
- Kept under pressure like water distribution system
- Sewage from individual house connection which is collected in a manhole on the site of the premises, is pumped into the pressure system,
- No provision of hydraulic gradient of sewer.

(c) **Vacuum Type System**:

- Collect foul runoff only in an airtight system

- A vacuum of 5-7 m is maintained in the system for collection and transportation of the sanitary sewage
- No provision of hydraulic gradient.

DESIGN OF SEWER

Objective of Sanitary Sewer Design using Separate System:
- Safe collection of waste water
-Safe disposal of waste water; safe disposal may require long transport lines (Discharge of Foul runoff <<< discharge of Surface runoff).

Objective of Storm Water Drainage Design:
-To prevent erosion in hill side areas (paved roads and terracing are needed)
-To prevent land slides
-To improve hygienic condition with regard to conveyance of sanitary sewage
-To limit inconvenience to people and traffic
-To limit damage of unpaved roads
-To prevent damage of housing, in case of elevation of ground floors to below street level

DESIGN METHODS:

Two Methods are available:
- ***Conventional method using Rational Formula***
- ***Advanced Method using Mathematical Models***

CONVENTIONAL METHOD:

ASPECTS TAKEN INTO CONSIDERATION

GEOGRAPHICAL ASPECTS:

*	TERRAIN:		
	Type:	Broken	Steep/Faint
		Flat	
*	BUILT UP AREA:		
	Type:	Compact	High/Low
		Sparse	Paved/Unpaved
*	WATER		
	Quantity	Large	Discharge points
		Small	Cleaned/Used
	Quality	Bad	Improve/Discharge
		Good	Discharge/Not
*	STREETS		
	Pattern	Even	Blacks/Green
		Irregular	Manholes/Bends
	Profile	Narrow	Two/One-sided
		Wide	Drains/Sewers
			Mains/Pipelines
	Condition	Paved	Gutters
		Unpaved	Improvement Plans

ENVIRONMENTAL ASPECTS

*	AREAS:	
	Rural Areas	Agriculture
		Tourism
	Residential Area	Houses
		Leisure Time
	Commercial Area	Shops/Artisans
		Markets
		Offices
		Hotels
		Heavy Industries
*	INFRASTRUCTURES	
	Main Roads	Traffic, Harbour
		Airport
		Industry
		Accidents
	Supplies	Drinking Water
		Electric Power
		Transport Facilities
	Sites	Pumping Stations
		Treatment Plants
		Construction Sites
	Open Water	Traffic
		Irrigation
		Drainage Discharge
		Sport/Tourism
		Drinking Water

URBAN PLANNING ASPECTS

RELATED TO CITY PLANNING :		
*	Population	Actual Figures
		Prognosis
		New Residences
*	Industries	Water Use
		Concentrations
		Singularities
		Dry/Wet
		Product Prognosis
		Sanitation (Tariff)
*	Areas	Paved Surface
		Prognosis
		Expansion
		Consignation
PUBLIC HEALTH RELATED:		
*	Consumption	Drinking Water
		Other Producers
		Prognosis/Planning

TRADE & ECONOMIC AFFAIRS RELATED:		
*	Industries	Future Development Type of Industries
*	Taxes	Income Level Political Preferences

DESIGN CRITERIA

*	TERRAIN	maps contour lines
*	AREA	urbanized area (roads: paved/unpaved) runoff coefficient inhabitants rate land acquisition
*	PRODUCTION	consumption inhabitants (whole yr./day pattern) shops, artisans & offices (yr./ only by day) industries (process) (yr./ 8 hr. a day)
*	GROUNDWATER	table infiltration rate infiltration condition
*	DELIVERANCE	peak factor round off margins
*	SEDIMENTATION	tractive force diameter particles minimum slope sediment transport
*	PRECIPITATION	rainfall data (distribution over the year) return period intensities
*	DISCHARGES	canal profiles water levels level margins
*	MAINTENANCE	skilled/unskilled manpower accessibility of drains
*	SWM	collection system dumping into drains or selected sites
*	SURFACE WATER COURSES	rivers(receiving water) ponds, low land, beel chara, channel, khal
*	EXISTING DRAINAGE CAPACITY	existing condition primary/secondary/tertiary
*	FLASH FLOOD	steep slopes tendency for scouring or non-silting vel constant water ways removing siltation and blockage
*	SYSTEM	pressure/gravity/vacuum control gates, sluices etc.,

DESIGN SYSTEM

DESIGN CONSIST OF FIVE MAIN PARTS:

1.	SETTING UP OF FLOWS		
	*	DRY WEATHER FLOW	actual/future design
	*	RAINFALL	drainage system design storm
2.	SEWER DESIGN CRITERIA		
	*	SLOPE SEWERS	
	*	CAPACITY OF SEWERS	sanitary sewer for 40% -50% full flow
3.	SETTING UP OF STRUCTURAL DESIGN		
	*	MAP WITH:	
		# service areas	drained sections
		# street sewers (scale 1:2000)	system lines flow direction
		# mains (scale 1:10,000)	sanitary/storm combined
		# discharges	drainage outlets sewers' discharges overflow constraints
4.	CALCULATION OF MAIN		
	*	discharges	flows/velocities
	*	constriction	depth/slope filling rate
	*	check	concentration time
5.	HYDRAULIC GRADE LINE IN MAIN		
	*	starting point	level overflow
	*	graph	standard grade line
	*	check	water level

DRY WEATHER FLOW (DWF)

DWF is composed of
- Domestic Waste Water
- Industrial Waste Water &
- Infiltration of Ground Water

DWF is measured
- in Sewers
- at Pumping Station or
- at Treatment Plant or
- from Water Consumption Figures

For measuring DWF we have to take the following under consideration:
-Population & demand
-Water Consumption/Capita
-Waste Water Production
- Infiltration of Ground Water
- Flow Variation:

Peak Flow = Q_{maxm} = p x $Q_{av.}$

where p = 1.5 + 2.5/($Q_{av.}$)^{5} and $Q_{av..}$ = Average flow in l/s.

QUANTITY OF RAINFALL/DRAINAGE RUNOFF

Use RATIONAL FORMULA:

Q = CIA

where Q = Peak flow in l/s

C = Runoff Coefficient which is a function of catchment characteristics

I = Rainfall intensity in l/s-hac corresponding to concentration time T_c where,

T_c = inlet time T_0 + flow time T_f;

A = Area contributing storm area i,e, catchment area upstream of the point under consideration I n hactre.

Alternatively, **Q = i/360(CIA)**

where Q = Peak flow in cumec/s

C = Runoff Coefficient which is a function of catchment characteristics

I = Rainfall intensity in mm/hr corresponding to concentration time T_c

where T_c = inlet time T_0 + flow time T_f

A = Area contributing storm area i,e, catchment area upstream of the point under consideration in hactre.

Also by Continuity Equation, **Q = av**

where a = wetted cross sectional area in sq. m and v = velocity of flow,

Using Manning Equation, **v = 1/n($R^{2/3}$ $S^{1/2}$)**

where R = Hydraulic radius (m) = area in sq, m/ wetted perimeter (P) in m.

S = Slope of the drain (m/m)

n = Manning Roughness Coefficient

Find S and using S, v, R etc, check for T_c and dia of sewer by trial and error

TRACTIVE FORCE METHOD:

Another method known as Tractive Force can be used for designing sewer using the ratios

-. Q/Q_{full}

-v /v_{full}

- h/D and

-R/D with the help of the design charts

Q_{full} = av_{full} = n/4 (D2) v_{full} = n/4 (D2) 1/n($R_{full}^{2/3}$ $S^{1/2}$)

Again R_{full} = A_{full}/(D_{full}) = n/4 (D2)/(nD) = D/4

Consequently, **Q = n/4 (D2) 1/n(0.254D_{full})$^{2/3}$ (S)$^{1/2}$**

= 23.42 (4D_{full})$^{8/3}$ (S)$^{1/2}$ cumec/sec

D = 0.306 (Q)$^{3/8}$ (S)$^{-3/16}$ m .

LAYING OUT OF SEWER SYSTEM

Procedure:

1. Contour Map with Contour Line
2. Possible Location for Disposal of storm water and foul sewage

3. Determining direction of overland flow pattern in system map from contour map
4. Considering alternate lay-out for sewerage system
5. Drawing the design lay-out of sewer system
6. Determining the boundaries of draining area

Technical Aspects:

- Minm. Coverage is 1 m
- Limiting depth of sewer in ground water to 4m
- Avoiding pumping for storm sewer but not for sanitary sewer
- Avoiding the provision of parallel deep sewer in order to limit the total construction cost
- Storm water should be discharged as directly as possible to the nearest water course.

ADVANCED DESIGN USING ENVIRONMENTAL MATHEMATICAL MODEL

Mathematical Simulation can be used for Urban Drainage Design .

Four types of Models are available (wa PUG, 1993) :

TYPE I - SKELETAL PLANNING, COURSE MACRO or PLANNING MODEL:

-Used for examining the overall hydraulic performance of the complete catchment or to simulate the flow condition at a specific location or section of a sewer
-May be used at the initial stage of rehabilitation study
-Would be used to simulate the outflow at a particular location within the system

TYPE II - DRAINAGE AREA PLANNING MODEL

-Used to assess the hydraulic performance within a specified drainage area with a view to identifying the sewer lengths in which there is a hydraulic problem

TYPE III - DETAILED DESIGN MODEL

-Used for detailed investigation of the performance of the existing system and alternative upgrading options
-Used for the detailed design of selected schemes

TYPE IV - SEWER QUALITY MODEL

- Used to have the information about quality of sewage in the sewer
- Pollution load in the sewer
- Quality of DWF
- Erosion & transport of sediment
- Pollution load associated with DWF
- Pollution load associated with the wash-off of the pollutants from the catchment area
- Pollution retention efficiency of any ancillary structure etc.

14 Operation and Maintenance of WSS Services

Introduction

The main source of drinking water supply in Bangladesh is the underground water. It is being extracted by different kinds of Tube wells and some other technologies. Drinking water supply normally consists of hand tube wells and piped water supply system. HTWs are aimed for the poor people living in the rural areas and fringes. Piped supply system are constructed for both poor and rich people living in the core areas of the urban centres. The characteristics of the two system are different particularly in terms of investment and operation and maintenance costs.

The defecation practices is still traditional and unhygienic. Only 44% people uses some form latrines. This includes different types of latrines. Solid waste management is still not a problem in the rural areas, but it is becoming a great environmental threat in the urban centres.

The cost of investment for HTWs is relatively less than that of piped water supply system. The per capita investment cost for shallow, deep and TARA varies from Tk 50 to 80, Tk. 500 to 600 and Tk. 100 to 150 respectively. On the other hand per capita investment cost varies from Tk.15,000 to 40,000 for having water supply system with production wells, pipe lines, overhead tanks, iron removal plant etc. It has also been observed that in many towns the current demand for new house connections is very limited. The cost for sanitary latrines also vary widely depending on the type.

The value of investment on fixed assets was never accounted for and no provision for depreciation was made. The hardware for water supply were mainly installed by DPHE under different projects financed by the Government or donors with the understanding that the Pourashava or the users will take over the responsibility of O&M of the system. In no town the Pourashava actually took the responsibility of O&M. But as an utility service the pumps were kept running by DPHE without taking into account the O&M cost recovery. Shallow hand tub wells are already popular in low water table area and being installed and maintained by the local mechanics in the private sector. But Deep HTWs and TARA are still financed by the public sector including maintenance. With that background, emphasis has been given on cost recovery for sustainability of water supply.

For the pourashava water supply the water supply section (PWSS) must be organized in all towns and accounting system to be implemented. At the same time performance of the PWSS to be increased to reach the sustainable level.

In the beginning most of the facilities were provided by the government and donors free of cost. But availability of facilities did not ensure utilization of the facilities. It had been seen that once the facility went out of order, it remained out of order. There was no fund for repair and maintenance of the same. That resulted needs for rehabilitation and caused more scarcity. The facilities must be constructed and optimally used before it is replaced.

Sustainability of WSS system:

Sustainability of the water supply and sanitation system must be considered for achieving good health for all and keep the environment healthy. With the increase in population we are facing extreme crisis of all resources including the water. With the passage of time drinking water is becoming scarce and environmental pollution is increasing.

The water supply and sanitation system will be called sustainable when the users can have guaranteed supply of safe water supply and sanitation facilities according to the demand. The main parameters for sustainable WSS system are considered as:

- Recovery of investment cost from the users as depreciation which is required for meeting future demand and replacement of the facilities.
- Recovery of operation and maintenance cost to keep the facilities in serviceable conditions
- Community participation in sharing the cost and undertaking operation and maintenance
- Community mobilization for use of safe water and use of sanitary latrines
- Participation of women in operation, maintenance and decision making.

Sustainability may be defined as the ability to meet the required operation and maintenance cost and to generate small surplus money to undertake replacement and extension work for improving service delivery in the town.

For sustainability at least some percentage of depreciation cost should be added with the tariff. That will be required for replacement of components and emergency maintenance and small extension work.

Estimated Cost for water supply and sanitation facilities

The estimated investment and monthly operation and maintenance cost of different kinds of facilities are shown below:

ITEMS	ESTIMATED COST PER UNIT IN TAKA	
	Investment cost	**O&M Cost(Month)**
HAND TUBE WELLS		
Deep HTW	50,000 to 70,000	50-75
Shallow	5,000 to 8,000	50-75
TARA	10,000 to 20,000	50-100
Pond sand filter	20,000 to 30,000	100-500
Shrouded Tubewell	10,000 to 20,000	100-500
Iron removal unit	5,000 to 10,000	100-200
PIPED WATER SUPPLY		
Pipe line / km	8,00,000 to 12,00,000	5,000-6,000
Production well	15,00,000 to 20,00,000	15,000-20,000
Treatment plant	100,00,000 to 15,00,000	20,000-30,000
Overhead tank	60,00,000 to 100,00,000	1,000-1,500
House connections	3,000	200-300
Street Hydrants	3,000	200-300
LATRINES		
Home made	100 to 200	20-30
Single Pit (1 ring + 1 slab)	225 to 300	20-30
Single Pit (5 ring + 1 slab)	1200 to 1500	20-30
Double pit (10 ring + 1 slab	2500 to 3000	30-50
Full sanitary latrines	20000 to 50000	100-200

The estimated cost shows the importance of cost recovery. For any facilities some one should bear the cost for installation as well as operation and maintenance. There is no way to treat the investment as free of cost. Similarly if the facilities are to be optimally used it must be maintained properly. In the urban centres the poorer people should also be served with the pipe water supply and sanitation facilities. The key point is to share the cost by the users. Community participation and skill development is very important.

Operation and maintenance cost:

The main items of operation and maintenance cost of water supply are:

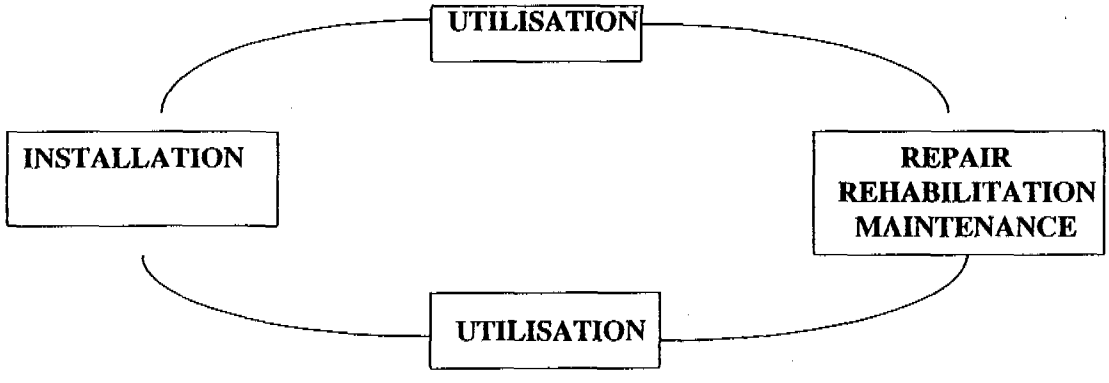
- Electricity bill
- Salary of staff
- Repair and Maintenance
- Office expenses

There is no operation cost for HTW but incur small amount of maintenance cost. The piped water supply system incur large amount of operation cost such as electricity bills, salaries of staff as well as maintenance costs such as repair and replacement of parts, components. Because of differences in the total investment cost the depreciation cost also vary widely between the HTW and piped water supply system.

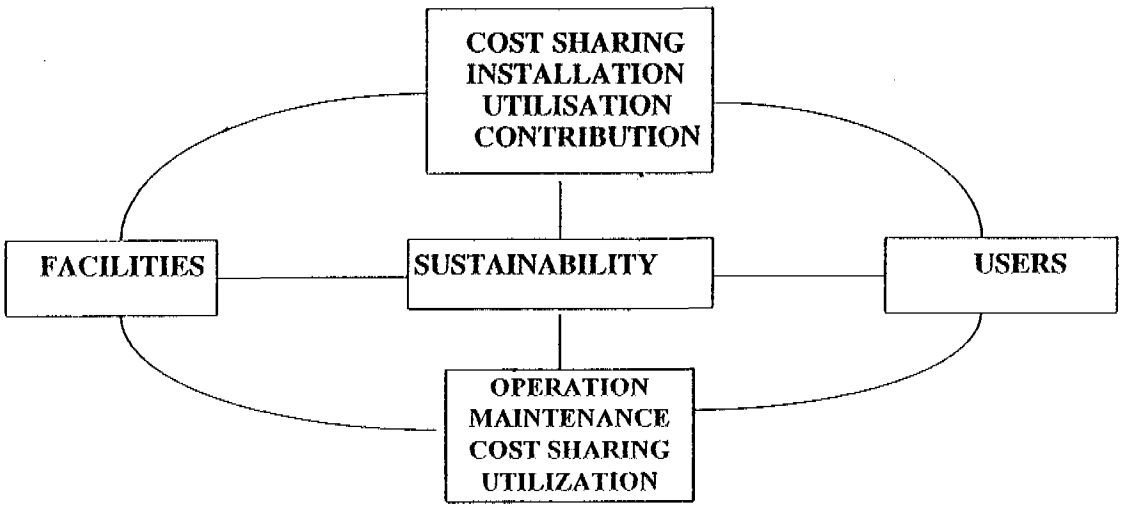
The number of house connections and the corresponding water tariff are not enough to generate sufficient revenue for meeting the O&M costs. For many towns it would not be possible for payment of the electricity bill which is about Tk. 10,000 per month per pump for 12 hours operation in a day. The salaries amounts to Tk. 15000 to 25000 per month depending on the no. of staff.

Most of the facilities failed to serve the purpose because of poor maintenance. If the users are trained for minor operation and maintenance of the facilities then they can keep it in good order by themselves. The installation, utilization and O&M are to be linked together to achieve sustainable WSS system.

Relationship between Installation, Utilisation and maintenance:



The monthly operation and maintenance cost for small pipe water supply system amounts to several lacs Taka. For HTWs and other technologies the charge would be at lesser rate. This amounts to be realised from the users if the pourashava or the agencies provide the maintenance. In other case the users may pay to the caretaker for buying and fixing the materials to the HTWs. In case of pipe water supply they can generate fund for payment of water bills. Thus the key to sustainable water supply and sanitation is the full involvement of the users in the system. The linkage between the users, the facilities and sustainability is shown as:


COST SHARING
INSTALLATION
UTILISATION
CONTRIBUTION
FACILITIES
SUSTAINABILITY
USERS
OPERATION
MAINTENANCE
COST SHARING
UTILIZATION