The Role of Sewage Treatment in Public Health

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Water supply and sewerage is a commonly used phrase. However, in many developing countries, “water supply” has higher priority over “sewage treatment”. Although clean water supply helps improve health condition, sewage treatment is as important because poor sanitation is the cause of water contamination, which causes many types of diseases. If sewage treatment is not appropriate, water-related diseases will spread to the human environment. In this write up, various types of diseases and the transmission routes are described. The efficiency of sewage treatment, drainage management, the role of primitive treatment and public health aspects of wastewater is also discussed.

HEALTH PROBLEMS RELATED WITH SEWAGE

Diseases Caused by Human Excreta

In human excreta, there are various types of diseases - causing pathogens whose transmission routes and control measures are quite different. The main biological pathogens are virus, bacteria, protozoa and helminthes. As for transmission routes, there are different types of contamination from simple faecal-oral contamination, water-borne route to complicated parasite infections. Basically, faecal infection can be classified into six categories as shown in Table I according to epidemiological features of such diseases.

The transmission routes of above mentioned diseases are shown in Figure 1. Each disease has its own transmission cycle from one patient to another, sometimes with water, soil, vectors or cattle in between. The objective of sewage treatment is to cut these cycles and prevent disease transmission. Figure 1 also shows a “sanitary barrier”, which includes various types of control measures. For example, the barrier can be “hardware” such as the provision of water supply and sewage treatment facilities or chemicals. In areas where costly treatment are not affordable, “software” such as health education or community participation is essential to enhance the barrier. Maintenance of drainage or tertiary wastewater collection pipes sometimes requires the cooperations of users, which helps reduce cost.

Water-related Diseases

Water related diseases could be classified into four types depending on it’s transmission route. For the control of each type of diseases, sewage treatment plays various roles. A summary of preventive strategies of water-related diseases is shown in Table 2.

- **Type I - Water-borne Diseases**
  Infections in this category spread through drinking water/food contaminated by excreta etc. Cholera, typhoid and ascariasis fall in this category. When sewage is not properly treated or disinfection is not satisfactory, such diseases can be spread. From poorly maintained on-site systems or from open defecation sites, such diseases can spread through groundwater flow or surface flow. Special attention should be paid when there is an outbreak of diarrhoea diseases epidemics because water can immediately disperse such diseases.

- **Type II - Water-washed Diseases**
  Diseases in this category are caused by the lack of proper hygiene due to water scarcity. Example of such diseases are skin/eye diseases (due to the lack of water to wash body) or lice/flea bornediseases (due to lack of water to wash clothes). The main cause of outbreak of diseases is the absence of water supply systems and clean water sources and surface/ground is heavily polluted with wastewater. Sewage system is responsible for the protection of water resources to control water-washed diseases.

- **Type III - Water-based Diseases**
  In this category, water provides the habitat for intermediate host of parasites. One typical example is schistosomiasis. This disease is caused by the discharge of human faeces or urine where there are snails, which serves as the intermediate host.
  The construction of sewage system can prevent this disease by reducing the contact frequency between men and snails. Construction of concrete lined drainage will...
### Table 1. Environmental Classification of Excreted Infections

<table>
<thead>
<tr>
<th>Category</th>
<th>Infection</th>
<th>Environment transmission focus</th>
<th>Major control measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Active; low infective dose</td>
<td>Amebiasis, Balantidiasis, Enterobiasis, Entero viral Infections, Giadiasis, Hymenolepiasis, Infectious Hepatitis, Rotavirus Infection</td>
<td>Personal Domestic</td>
<td>Domestic water supply, Health education, Improved housing, Provision of toilets</td>
</tr>
<tr>
<td>II. Active-latent; medium or high infection dose; moderately persistent; able to multiply</td>
<td>Campylobacter infection, Cholera, Pathogenic scherichia coil infection, Salmonellosis, Shigellosis, Typhoid, Yersiniosis</td>
<td>Personal Domestic Water Crop</td>
<td>Domestic water supply, Health education, Improved housing, Provision of toilets, Treatment of excreta prior to discharge or reuse</td>
</tr>
<tr>
<td>III. Inactive and persistent no intermediate host</td>
<td>Ascariasis, Hookworm infection, Strongyloidiiasis, Tricuriasis</td>
<td>Yard Field Crop</td>
<td>Provision of toilets, Treatment of excreta prior to land application</td>
</tr>
<tr>
<td>IV. Inactive and persistent; cow or pigs as intermediate host</td>
<td>Taeniasis</td>
<td>Yard Field Fodder</td>
<td>Provision of toilets, Treatment of excreta prior to land application, Cooking, meat inspection</td>
</tr>
<tr>
<td>V. Inactive and persistent; aquatic intermediate hosts (s)</td>
<td>Clonorchiasis, Diophyllobothriasis, Fascioliiasis, Fasciolopsiasis, Gastorodiscoidiasis, Heterophyiasis, Metagonimiasis, Opsthorchiasis, Paraginimiasis, Schistosomiasis</td>
<td>Water</td>
<td>Provision of toilets, Treatment of excreta prior to discharge, Control of animal reservoirs, Control of animal reservoirs, Control of intermediate hosts, Cooking of water plants and fish, Reducing water contact</td>
</tr>
<tr>
<td>VI. Spread by excrete-related insects</td>
<td>Bancroftin filarias (transmitted by Culex pipiens), All the infection in I - V able to be transmitted mechanically by flies and cockroaches</td>
<td>Various faecally contaminated sites in which insects breed</td>
<td>Identification and elimination of suitable insect breeding sites</td>
</tr>
</tbody>
</table>

*a. Includes polio-, echo-, and coxsackie virus infections
b. Includes enterotoxigenic, enteroinvasain , and enterooathogenic E. coil infections
c. Ancylostoma duodenale and Necator americanus*

### Table 2. Four Types of Water-related Transmission Route and appropriate Preventive Strategies.

<table>
<thead>
<tr>
<th>Transmission route</th>
<th>Preventive Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type I - Water-borne</td>
<td>Improve quality of drinking water, Prevent casual use of unprotected</td>
</tr>
<tr>
<td>Type II- Water-washed (or water-scarce)</td>
<td>Increase water quality used, Improve accessibility and reliability of domestic water supply</td>
</tr>
<tr>
<td>Type III - Water-based</td>
<td>Improve hygiene, Reduce need for contact with infected water, Control snail populations</td>
</tr>
<tr>
<td>Type IV - Water-related insect vector</td>
<td>Reduce contamination of surface waters, Improve surface water management, Destroy breeding sites of insects, Reduce need to visit breeding sites, Use mosquito netting</td>
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</table>

* Applies to schistosomiasis only
contribute to control this diseases because the number of snail hosts will be significantly decreased due to the high water velocity in the improved drainage.

- **Type IV - Water-related Vector-borne Diseases**
  The examples of this category are malaria and filariasis. Such diseases are transmitted by mosquitoes, which propagate in water. Provision of good drainage systems as well as sewer system reduces the number of casual water pools, which contributes to the control of vectors such as mosquitoes.

**TYPES OF SEWAGE CONTAMINATION**

- **Groundwater Contamination and Diseases**
  As for the primitive sewerage systems such as pour flush and pit latrines, biological and chemical contamination may occur when leachate is discharged to the ground. Biological contamination causes diseases as was already mentioned in Table 1. Although biological contamination causes acute and severe illness, the influenced area by an on-site systems is not wide because the pathogens are trapped among soil particles and die after certain period. Instead, chemical contaminant such as nitrate, are accumulated in soil and remain for a long time. Groundwater which contains large amount of nitrate may cause blue-baby syndrome when it is used in melting powdered milk and given to babies.

- **Groundwater Contamination Caused by On-site Systems**
  Primitive systems are commonly used in rural areas where sewage system does not exist. These systems are quick improvement measure to prevent diseases where there are open defecation practice or unsanitary disposal facilities such as overhung latrines. However, primitive sewerage systems become biological/chemical pollution sources when they discharge poorly treated wastewater to the environment. Some primitive treatment systems such as pit latrine or leaching pit discharge liquid into the groundwater.

  The behaviour of leachate from pit latrine differs depending upon permeability of soil, groundwater level and flow direction. Well water contamination level is different according to the depth of groundwater intake points and the condition of aquifers.

  From the above discussion, it can be concluded that special attention should be paid to the following factors if on-site sanitation systems and shallow wells are closely located. 
  - Distance between on-site sanitation systems and shallow wells
  - Condition of aquifer (confined or unconfined)
  - Depth of water intake point from well water

- **Contamination of Surface Water**
  Sewage treatment without disinfection before discharge, can be a biological pollution source. Even though disinfection chamber is equipped, it is often the case that there is no disinfectant in the chamber. This is partly because of users’ low interest in the protection of environment and partly because of low affordability.

  Centralised Sewage Treatment system also has the risk of such contamination. In conventional sewage treatment systems such as activated sludge method, detention time is not long enough to kill biological pathogens. Therefore, chemical disinfection becomes a prerequisite to eliminate the biological pathogens. If maintenance of disinfection is not enough, it may create health problems.

**THE RELATIONS BETWEEN THE ENVIRONMENT AND PUBLIC HEALTH**

  Usually the main objective of sewage treatment is the removal of contaminants to the environment such as BOD, SS, T-N, T-P etc. and reduces the burden to the “environment”. However, another important aspect of sewage treatment is the reduction of pathogenic agents, which affect “human health”. In areas where water-borne diseases or infections are prevalent, such health aspects are far important that the environmental aspects.

  Disinfection of pathogenic micro-organisms is done either by chemicals, temperature or time. In urban areas, common practice is to use chemicals such as chlorine compounds, disinfectants. This is the most reliable and less land requiring measure. However, the operation and maintenance cost for chemical disinfection is high. There are other disinfection methods using ultraviolet radiation, ozonation etc. Most of them are costly and not appropriate in developing countries except special places such as a tourism complex.

  Another way of disinfection is to kill microorganisms by exposing them to certain high temperature for enough time to kill them. The relationship between temperature and dying-off time is shown in Figure 2 (Feachem et al., 1983). The figure takes into account numerous data taken in the environment. This figure shows that the vibrio cholera dies relatively soon at medium temperature but ascaris eggs are viable for years at normal temperature. Some pathogens even multiply in the environment if conditions are specifically good for their multiplication. This figure is also applicable for sludge treatment such as anaerobic digestion or composting. If composting is used as the sludge treatment method, compost pile should be turned over so that all parts of sludge in the sludge compost pile should come into the center of the pile where temperature is high enough to kill pathogenic agents.

  In conventional sewage treatment plants, treated wastewater is normally disinfected with chemical such as chlorine compounds. However, in developing countries, willingness to pay is very low for sewage treatment, which sometimes becomes a barrier to use chemical disinfection system. In such a case, disinfection should be done considering temperature and detention time as shown in Figure 2. If the availability of land allows a long detention time and the ambient temperature and sunshine strength around the treatment plant are good enough for the treatment, chemical disinfecting is not necessary.

  The relationship between detention time and removal efficiency for pathogens are shown in Figure 3 (Shuval, 1990). From the figure, parasite eggs are considered to settle down within 8–11 days in the ponds. If detention time in the ponds is long enough, they are almost removed.
In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account, and the guidelines modified accordingly. Ascaris and Trichuris species and hookworms during and irrigation period. A more stringent guideline (200 faecal coliform per 100 ml) is appropriate for public laws, such as hotel lawns, with which the public may come into direct contact. In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.

and treated wastewater becomes safe parasites. As the sludge residence time is very long in such ponds, most of removed helminthes eggs die in the sedimentation in due course. As for bacteria, considerable decrease in coliform is achieved through the treatment in the ponds. Normally, such a long hydraulic/sludge residence time can only be achieved by waste stabilisation ponds. Treated wastewater from such ponds can be discharged to the environment without disinfection. Despite these merits, stabilisation ponds are not used in areas where enough land is not available.

In many arid areas, sewage is used in agriculture or aquaculture without appropriate treatment. However, if wastewater is not properly treated, it may cause serious health problems such as the outbreak of diarrhoea diseases or ascrasis. The risk groups are the workers, such as farmers and fishermen, and consumers of crops. A microbiological guideline values recommended by WHO is typically shown in Table 3 (WHO, 1989).

**CONCLUSION**

Sewage treatment has two essential roles, first to protect public health and second to protect the environment. Trends and history around the world have shown that the early provisions of sanitary facilities were mainly health driven. This remains the same in many current developing and poor countries. The more developed and rich nations emphasise sewage treatment more for environmental protection.

**Table 3. Recommended microbiological quality guidelines for wastewater use in agriculture (WHO, 1989)**

<table>
<thead>
<tr>
<th>Category</th>
<th>Reuse condition</th>
<th>Exposed group</th>
<th>Intestinal nematodes a (arithmetic mean no. of eggs per litre b)</th>
<th>Faecal coliform (geometric mean no. per 100 ml c)</th>
<th>Wastewater treatment expected to achieve the required microbiological quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Irrigation of crops likely to be eaten uncooked, sports fields, public parks d</td>
<td>Workers, consumers, Public</td>
<td>&lt;1</td>
<td>&lt;1000 (d)</td>
<td>A series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment</td>
</tr>
<tr>
<td>B</td>
<td>Irrigation of cereal crops, industrial crops, fodder crops, pasture and trees e</td>
<td>Workers</td>
<td>&lt;1</td>
<td>No standard recommended</td>
<td>Retention in stabilization ponds for 8–10 days or equivalent helminth and faecal coliform removal</td>
</tr>
<tr>
<td>C</td>
<td>Localized irrigation of crops in category B if exposure workers and the public does not occur</td>
<td>None</td>
<td>Not applicable</td>
<td>Not applicable</td>
<td>Pretreatment as required by the irrigation technology, but not less than primary sedimentation</td>
</tr>
</tbody>
</table>

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a In specific cases, local epidemiological, sociocultural and environmental factors should be taken into account, and the guidelines modified accordingly.

b Ascaris and Trichuris species and hookworms
c During and irrigation period
d A more stringent guideline (200 faecal coliform per 100 ml) is appropriate for public laws, such as hotel lawns, with which the public may come into direct contact.
e In the case of fruit trees, irrigation should cease two weeks before fruit is picked, and no fruit should be picked off the ground. Sprinkler irrigation should not be used.