ADVERSE EFFECT OF SEWAGE AND SANITATION ON HUMAN HEALTH: A CHALLENGE TO DEVELOPING COUNTRIES

"For India, sanitation is more important than independence"

- Mahatma Gandhi

There is a continuous migration of people from rural and semi-urban areas to urban areas and on the other hand many cities have poor infrastructure services like water supply, sewage, storm water drainage and solid waste management. In many cities and towns in India, a large portion of the sewage remains untreated and hence results in an increase in morbidity due to pathogens and parasitic infections and infestations and thus it affects human health as well as environment [1].

According to the Census 2011, in India, open sources like tube well, tanks, hand pump and covered well etc. serve drinking purpose for 87% of the population. Availability of tap water from treated sources is limited to only 32% households. As per the Census, 18% still fetch drinking water from a source located more than 500 m away in rural areas or 100 m in urban areas [2]. As compared to urban population, rural population is less affected by the effects of pollution.

But they also face some problems because of illiteracy, poverty, ignorance and superstitions. Due to these reasons, they do not know the importance of sanitation & hygiene & hence results in the break out of a number of epidemic diseases like typhoid, cholera etc. Lack of drainage facilities & open defecation also add to the onset of various diseases [3].

Figure 1. Open defecation issue in India [Retrieved from https://www.livemint.com/news/india/under-nda-more-toilets-less-open-defecation-1552842931107.html]

WHAT IS SANITATION?

Sanitation deals with the water supply and human waste, which could be solid wastes, industrial and other special/hazardous wastes & storm water drainage. Among
these, most harmful is sewage. The decomposition of organic matter of sewage produce malodorous gases. It also contains various pathogens. In addition to that, sewage contains nutrients as well as toxic carcinogenic compounds. Therefore, treatment, reuse/ dispersal of sewage into the environment in an eco-friendly manner is necessary to protect public health and environment. For this, it is required to possess knowledge of-

1. Constituents of sewage
2. Impact of these constituents on environment
3. Transformation or fate of the constituents in treatment processes
4. Effective treatment processes
5. Appropriate disposal methods

As per the report of WHO, 80% diseases in humans are due to water pollution/ contamination. Diseases include diarrheal diseases, intestinal helminths, Trachoma, Hepatitis.

As reported by “The Economic Impact of Inadequate Sanitation in India”, over 50 million people in urban India defecate in the open every day. The cost to treat diarrheal diseases for children from poor sanitation is estimated to be Rs. 500 crores. The per person cost due to poor sanitation is estimated at Rs. 5400 & due to poor hygiene practices at Rs. 900.

The impacts of poor sanitation on human health are significant. Unsafe disposal of human excreta is responsible for the transmission of oral-fecal diseases, like diarrhea and a range of intestinal worm infections such as hook worm and round worm. Almost one-fifth of all deaths of Indian children, under the age of 5 years, are due to diarrhea. Rampant worm infection and repeated diarrhea result in widespread childhood malnutrition.

The economic loss is also very clear in terms of water treatment costs, losses in fisheries production, tourism, welfare impacts like reduced school attendance, inconvenience, wasted time, lack of privacy and security for women [1].

According to the 2017 WHO/UNICEF Joint Monitoring Programme (JMP) estimate, in 2015, 39% of the global population (2.9 billion people) used a safely managed sanitation service, 27% used private sanitation facilities where waste water was treated, 13% used toilets/latrines where excreta were disposed of in situ. The report also showed that 2.3 billion people still don't use basic sanitation services and 892 million people worldwide still practiced open defecation [4].

**IMPORTANT MEASURES**

In rural and urban India, following are some measures which should be taken into consideration to overcome the problem of sanitation [5,6]:

1. Publicity and sanitation education should be given to people to make them aware about the hazards related to poor sanitation.
2. Looking at the socio-economic status of the people, cheaper, native and acceptable sanitation technologies should be developed. To improve microbiological quality of the water, methods like boiling, filtration or chlorination should be adopted.
3. Steps should be taken to eradicate malaria.
4. Open defecation should be avoided. Safe disposal of children's stool has received relatively little attention. Most toilets are not designed for the use of such small children because many people consider that stool of breast fed infants is less harmful and they are also afraid of factors like risk of infant falling in, bad smells or the fear of dark spaces. But occurrence of diarrhea and higher egg counts of soil transmitted helminths (STH) in children, child stool showed greater health hazards than those of adults.
6. The poorer communities should adopt in incremental systems where upgrading and maintenance should be handled by the users.
7. Drinking water should be taken from a tube well. Providing safe, reliable, piped-in water to every household contributes to the Millennium Development Goal targets for poverty reduction, nutrition, childhood survival, school attendance, gender equity and environmental sustainability.
8. Bathing of animals in ponds should be avoided.
9. It is estimated that 70% of all diarrhea is caused by contaminated food. Therefore, food
hygiene practices like reheating foods, preventing contact with flies and hand washing before feeding are very important.

10. Hand washing with soap before and after feeding can interrupt the transmission of faecal-oral microorganisms in the domestic environment because hand washing with soap is reported to decrease the microbial count to nearly zero and can also reduce acute respiratory infections by 23%.

HEALTH HAZARDS

By using a stick broom and a small tin plate, the sanitary workers clear feces from private and public latrines onto basket and carry it on their heads or carts to dumping sites.

In addition to social atrocities, these workers are also exposed to various occupation related health issues like,

- Exposure to harmful gases, which include hydrogen sulfide, methane, ammonia and carbon monoxide. Due to this exposure, several symptoms are seen. For example, cough, chest tightness, sore throat, breathlessness, sweating, thirst, irritation etc.

- Musculoskeletal disorders, for example osteoarthritic changes and intervertebral disc herniation.

- Infections, like leptospirosis, hepatitis and Helicobacter pylori are common.
  1. Leptospirosis develop in workers, coming in contact with animals and their discharges. Rodents are mainly carriers. Leptospira are found present in the urine of the infected animals and hence infect sewers.
  2. Hepatitis A virus is the most commonly occurring disease among sewage workers. Therefore, they should be given vaccine against it.
  3. Helicobacter pylori, causes gastric cancer among sewage workers and this bacterium is considered as Class I carcinogen by International Agency for Research on Cancer.

- Some other infections associated with sewage workers are: intestinal parasitic infection, gastroenteritis and Pontiac fever.

- Dermatitis has been found among the sewage treatment workers engaged in incineration work.

- Respiratory problems are very common among sewage workers, which would be due to the exposure to endotoxins and airborne bacteria by means of bio-aerosols. Such workers are exposed to different occupational noxious agents, which may lead to chronic changes to lung function [7].

Category wise examples of excreta-related infections are shown in Table 1 [8].

REQUIREMENT OF SUSTAINABLE TECHNOLOGY

Now-a-days, housing, social services, health care and providing basic infrastructure like, clean water and the disposal of effluent are major challenges to the government and associated officials.

In India, per capita surface water availability in the year 1991 was 2300 m$^3$ (6.3 m$^3$ per day) and was 1980 m$^3$ (5.7 m$^3$ per day) in the year 2001 and these are estimated to reduce to 1401 and 119 per m$^3$ by the years 2025 and 2050, respectively. Centralized plants, pit latrines, septic system or disposed of in unmanaged lagoons or water ways, via open or closed sewages are few modes of domestic waste water treatments. In many developing countries, domestic and industrial waste water is discharged without any treatment or only after primary treatment.

In India, 27 cities possess only primary treatment facilities, while only 49 have primary and secondary treatment facilities. Reuse of waste water is carried out in irrigation, gardening, flushing, cooling of air conditioning systems, as a boiler feed and as process water for industries. For this reuse, a sustainable technology should be adopted which should consider following points:

1. Centralized and de-centralized technologies should be a felt priority in public or environmental health.

2. The technology should be cost-effective, require low energy input and mechanization.

3. The technology should be simple to operate, involve “local” labour, community driven and should be able to recover resources.

4. As per the need and to meet quality standards, the technology should be capable of being upgraded [9].

METHODS OF WASTE WATER TREATMENT

1. Activated Sludge
2. Bio-filteration/Trickling Filters
### Table 1. Category wise examples of excreta-related infections [8]

<table>
<thead>
<tr>
<th>No.</th>
<th>Category</th>
<th>Infection</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Non-bacterial faeco-oral diseases</td>
<td>Viral: Hepatitis A &amp; E, Rotavirus diarrhea, Norovirus diarrhea, Protozoan: Amebiasis, Giardiasis, Cryptosporidiosis, Helminthic: Enterobiasis, Hymenolepiasis</td>
</tr>
<tr>
<td>2</td>
<td>Bacterial faeco-oral diseases</td>
<td>Campylobacteriosis, Cholera, Pathogenic E. coli infection, Salmonellosis, Shigellosis, Typhoid, Yersiniosis</td>
</tr>
<tr>
<td>3</td>
<td>Geohelminthiases</td>
<td>Ascariasis, Hookworm infection, Strongyloidiasis, Trichuriasis</td>
</tr>
<tr>
<td>4</td>
<td>Taeniasis</td>
<td>Taeniasis</td>
</tr>
<tr>
<td>5</td>
<td>Water-based Helminthiases</td>
<td>Schistosomiasis, Chlonorchiasis, Fasciolopsis</td>
</tr>
<tr>
<td>6</td>
<td>Excreta-related insect-vector disease</td>
<td>Bancroftian, Filariasis</td>
</tr>
<tr>
<td>7</td>
<td>Excreta-related rodent-vector disease</td>
<td>Leptospirosis</td>
</tr>
</tbody>
</table>

3. Stabilization ponds  
4. Aerated lagoons  
5. Grit and Scum removal  
6. Oxidation ditches  
7. Anaerobic Rock filter  
8. Imhoff tank [9].

To overcome the health problems of sewage and sanitation, we need to adopt proper hygiene and various methods to treat the waste water. The detailed models of each treatment method is described below:

**1. Activated Sludge:**

It's the most common method of treating sewage by biological means. With the help of mechanical aerator, the sewage is aerated in an aeration tank. Using the available oxygen, the microorganisms present in the sewage metabolize the soluble and suspended organic matter. This helps in generation of new bacterial cells and formation of CO₂ and H₂O. These newly formed bacterial cells form flocs and known as sludge. This activated sludge is separated from the settling tank and returned back to the aeration tank, and recycled. Here this sludge serves as a seed to carry out next batch of process.

Oxygen is very crucial for this process so constant aeration should be provided. The excess sludge can be removed and after drying it can be used as a fertilizer in crop lands or as landfills. The type of reactor, food microorganism (F/M) ratio, nutrients, aeration, pH and temperature are most important factor affecting the efficiency of the activated sludge process.

If run under ideal conditions, this process can remove up to 98% of bacteria, 95% of suspended solids and up to 95% reduction in BOD (Biological Oxygen Demand). Generation of large volume of sludge, power consumption and supervision by
skilled workers are few drawbacks of this technique.

2. Bio-filteration/ Trickling Filters:

![Trickling Filter Diagram]

**Figure 3.** Trickling filter [Retrieved from https://www.slideshare.net/shuaibumusa2012/biotech-presentation-29686787]

It is also known as sprinkling or percolating filter. In true sense, they are oxidation units. It consists of bed of coarse, hard and porous material, over which sewage is sprayed. In about two week of time, biological film is formed over the bed, which is usually 0.1 to 2.0 mm thick and rich in microorganisms.

As the liquid sewage passes through the film, organic matter present in the sewage gets oxidized to CO₂ and NO₃. This process is carried out by the bacteria present in the biofilm. *Pseudomonas, Flavobacterium, Alcaligenes, Ulothrix* etc. and some fungi and yeasts are commonly found in the biofilm.

Trickling filters are simple, require less space and cost of operation is also low. They are efficient to work under hot climate so suitable for most developing countries like India. It can not handle raw sewage and therefore primary sedimentation process is necessary.

3. Stabilization ponds:

![Stabilization Ponds Diagram]

**Figure 4.** Types of stabilization ponds [Retrieved from https://en.wikipedia.org/wiki/Waste_stabilization_pond]

Anaerobic, facultative and aerobic ponds are three types of stabilization ponds.

I. Anaerobic pond: It is used to treat sewage with high-strength organic content. It is devoid of dissolved oxygen. Due to their deep construction, these ponds require less construction area as well as makes heat conservation possible. Sewage is precipitated and converted to CO₂, methane and other gases, organic acids etc. This process removes 75% of the BOD.

II. Facultative pond: It employs aerobic, anaerobic and facultative types of microorganisms. Aerobic bacteria and algae are found present on the surface. Anaerobic bacteria and solids that undergo decomposition are found in the bottom. Intermediate zone is occupied by both aerobic as well as anaerobic bacteria as this zone is partly aerobic and partly anaerobic. Algae carry out photosynthesis and release oxygen, which is used by aerobic and facultative bacteria to oxidize soluble organic matter. Solids present in bottom zone is degraded by anaerobic bacteria and converted to CO₂, CH₄ and H₂S. Initial and operating cost is low as well as no skilled personnel are needed. Good aeration should be provided to surface zone otherwise foul gases cause nuisance to the surrounding. Other than this, mosquito breeding and large land area for construction is required.

III. Aerobic pond: They are used for treating soluble waste and mainly consist of algae and aerobic bacteria. Some protozoa and rotifers also help in the treatment of effluent. The operation requires the presence of oxygen. These ponds are constructed at a depth of 150 to 450 mm which allows the penetration of light. There exists a symbiotic relationship between algae and aerobic bacteria. Algae produce oxygen through photosynthesis which is used by the aerobic bacteria. These bacteria then degrade organic matter in the sewage and generate CO₂ and other nutrients, which are used by the algae for their growth. Species of algae and bacteria, quality & quantity of organic matter, aeration, pH, temperature, sunlight, nutrients are some of the contributing factors which are important for the successful operation of the pond.
4. Aerated lagoons:

Figure 5. Aerated lagoons [Retrieved from http://archive.sswm.info/category/implementation-tools/wastewater-treatment/hardware/semi-centralised-wastewater-treatments-0]

In this, surface aerators are installed to overcome the bad odors. The treatment of sewage is similar like that of activated sludge. The major difference is larger surface area and hence temperature fluctuations affect it.

5. Grit and Scum removal:

Figure 6. (A) Grit chamber; (B) Skimming tank [Retrieved from http://www.biologydiscussion.com/waste-management/waste-water-treatment/processes-of-waste-water-treatment-4-process-with-diagram/10989]

Grit removal is considered primary treatment. It is based on the principle of sedimentation and used for the removal of sand, ash etc. by employing grit chambers.

Skimming tanks are used for the removal of greasy and oily matter like fats, oils, waxes, soaps from the sewage. Here, compressed air is pushed from the base of the chamber, which coagulate and solidify the oily and greasy matter. This material is then removed manually or mechanically from the upper layer.

6. Oxidation ditches:

It consists of two or more ditch channels constructed side by side and are constructed by brick or stone masonry. A special type of rotor, fitted into each ditch channel provide continuous oxygen supply and mixing of sludge. Sedimentation tank allows the sludge to settle down. Instead of using separate sedimentation tank, the sewage can be allowed to settle by stopping the rotors during night.

Figure 7. Oxidation ditch [Retrieved from http://www.ques10.com/p/32965/short-note-on-oxidation-ditch/]

7. Anaerobic Rock filter:

Figure 8. Anaerobic rock filter [Retrieved from http://www.waterpathogens.org/node/5251]
It consists of a column which is filled with solid media. This solid media provides the base for the anaerobes to remain attached or present in the column. Sewage passes through the solid media, to which anaerobic bacteria are attached. The treated effluent can be recycled back to maintain the flow rate.

8. Imhoff tank:

It is basically a two story tank. In the upper tank, sedimentation takes place, and in the lower compartment, digestion of the settled solid takes place. When sewage enters the sedimentation tank, solids settle down to the bottom and slop (slot overhang) help sewage to go into the digestion chamber. Sludge can be collected periodically from the bottom [10].

![Imhoff Tank Diagram](https://www.semanticscholar.org/paper/Honduran-Imhoff-Tanks%3A-Potentials-and-Pitfalls-Mikelonis-Herrera/423608c2ac1db82207d1127e77eac41ee4fd2cce)

**Figure 9.** Imhoff tank [Retrieved from https://www.semanticscholar.org/paper/Honduran-Imhoff-Tanks%3A-Potentials-and-Pitfalls-Mikelonis-Herrera/423608c2ac1db82207d1127e77eac41ee4fd2cce]

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