WASTE WATER MANAGEMENT

By Shivshankar Ranganathan

Waste water is generated as a result of any human activity that involves the use of water for any purpose. These activities are domestic, agricultural and industrial/commercial.

Domestic. Domestic uses of water are for washing, bathing, cooking and flushing toilets. Where water is used for washing and bathing, it results in the water being contaminated by food residues, oils, grease, soap and detergents. This waste water is commonly referred to as ?grey water? or ?sullage?. Water used for flushing toilets is referred to as ?black water? or ?sewage?. The former is easier and cheaper to treat, while the latter is more difficult to treat and hence treatment is costlier. For the sake of convenience and because water was till recently available in sufficient quantities, both these types of waste were combined at the drainage outlet. In large cities and towns underground drainage or sewers convey this waste to treatment facilities where available. More often than not, the waste water is pumped or drains into a river or a lake. In coastal areas it is invariably drained or pumped into the sea. The logic was at that time, the receiving body was large enough to dilute the waste. Unfortunately, this situation changed long ago, and the concerned authorities just continued to ignore the problem.

Industry. In industry or in commercial establishments, water is predominantly used for heating and cooling. Both these industrial and commercial applications of water result in an increase in the dissolved solids content of the water increasing to unacceptably high levels. Water used in industries, depending on the type of industry also comes in direct contact with either product being manufactured or the raw material at some stage and gets contaminated. In addition, since water comes into prolonged, intimate contact with metallic surfaces (when used for cooling and heating), it picks up metallic and chemical contaminants. Many manufacturing processes result in very severe and heavy contamination of the water used for the process, and in some cases produce very large volumes of waste water. Paper mills, steel mills, tanneries, pharmaceutical units, distilleries, breweries, fertilizer manufacture, oil refining, synthetic fibres are just some of the many industries that produce highly contaminated and large volumes of waste water.

Agriculture. Modern agriculture, particularly those practices established by our ?green revolution? resulted in contamination of water by fertilizer and pesticide residues due to ?run offs? caused by large irrigation schemes.

Wastewater Statistics

The data published by the Central Pollution Control Board (CPCB) for the year 2005 show that the volume of waste water from urban centres (domestic sewage) in India is 22900 Million Litres Daily (MLD) while the existing treatment facilities for this sewage can handle only 5900 MLD.

Industrial waste water on the other hand is 13500MLD and the existing treatment facilities can handle 8000 MLD all of which has been installed by industries which generate this waste water. The balance 5500 MLD comes from Small Scale Industries (SSIs) located in residential areas!

Untreated domestic sewage forms the single largest source of coastal marine pollution with 90% of the waste water flowing into the sea being untreated waste water. If pollution keeps pace with population growth, the current figure of pollution is that one litre of waste water pollutes about 8 litres of fresh water, this would result in ALL available sources of ?fresh? water getting polluted by 2051. Clearly waste water management needs to be actively practiced instead of being talked about.

Types of Waste water:
The most commonly present types of waste water are domestic sewage and industrial effluents. Agricultural ?run offs?,since they enter lakes, rivers and other water bodies is not taken as waste in the strict sense. The most significant characteristic of domestic sewage is the BOD (biodegradable oxygen demand) due to contamination by organic matter and faecal contamination and also the COD (chemical oxygen demand).

Industrial waste water on the other hand varies in characteristics depending on the type of industry that generates it. Industries like distilleries, paper mills, textile processing units, fertilizer units, oil refineries, tanneries, steel mills, etc produce effluents which have extremely high levels of BOD and COD, high levels of inorganic impurities and toxic heavy metallic impurities. In some cases, the volume of waste water generated is very high(eg, paper mills).Many industrial waste waters with such characteristics need extensive and expensive treatment to make them fit for discharge as per the norms specified by the Pollution control authorities. This was till some time back seen as an unproductive expense and the waste was clandestinely disposed off. Increasingly stricter enforcement of pollution control laws and reduced availability of fresh or raw water for industries has drastically altered this situation and investment in facilities to handle such waste water is increasing.

Effects of Pollutants:
a) Sewage:
Organic matter consisting of proteins, carbohydrates, and fats measured in terms of BOD and COD lead to depletion of all the oxygen in the water into which sewage enters. Nitrogen and phosphorus Result in the extensive growth of algae and eutrophication of water. Suspended solids, both organic and inorganic leads to sludge deposits and subsequently to anaerobic conditions. Bacteriological contamination due to the prescence of faecal coliform bacteria is particularly harmful to human beings. All these contaminants render the water unfit for any kind of human use and for several other uses, including industrial.

b) Industrial Waste Water:
Organic matter is present in practically all industrial wastes and in many cases is caused in addition to the organic similar to that in sewage, by complex organics which are difficult to degrade. Many industrial waste waters have BOD and COD levels many times higher than in sewage due to this. In addition, toxic heavy metals, dyes and very high levels of dissolved solids are also present in industrial waste waters depending on the type of manufacturing process that generates the waste water. Again, such pollutants beside making water containing them unfit for industrial use, also makes water dangerous for any living being that consumes it, not to mention the fact that it will first kill off all aquatic life and destroy the aquatic eco system it has polluted.

Treatment Methods:
Nature?s way of handling waste is time tested and proven. Whether on land or in water, microbes consume any waste and clean up the ?mess.? In the case of water too, the same system works. Microbes consume or degrade the waste and use oxygen to survive and multiply. It is because of this that the terms BOD and COD are relevant. Any waste water which contains organics has an oxygen demand, and, as long as this demand is continuously met, the organic matter is degraded till it is no longer present. This phenomenon has been used to treat waste water, and is commonly called as biological treatment.

In the case of sewage, it is first allowed to flow into an equalization or collection tank which evens out fluctuations in flow rate and homogenizes it. Next is a primary treatment where all physical and solid matter (called grit) is removed using ?grit screens?. The sewage then flows into aeration tanks/basins where air is ?supplied? to the sewage to allow the microbes or bacteria to degrade the contamination. Aeration of the sewage is done by using either high speed surface aerators or now, increasingly by diffusers at the bottom of the tank/basin which allow air bubbles to continuously rise upwards through the sewage. This is a better method than high speed aeration and is less energy intensive. It is referred to as ?extended aeration?.

In the next stage, known as the secondary stage, the sewage is subjected to clarification where the dead microbes and degraded organics is settled and drawn off periodically as sludge, allowing clear water with about just 10 to 15% of the original BOD and COD to flow into tanks from where it is discharged to open bodies of water(lakes/pond, etc), or rivers or even to the sea.

A final, tertiary treatment method can be used which subjects the clear sewage to pressure filtration using sand beds and activated carbon beds, and chlorination or ozonation to make the treated sewage suitable for a number of industrial uses as well as uses such as gardening, floor washing , etc.

Treatment of industrial waste water follows much the same process except that in many cases, the chemical impurities present are settled and removed after using specific chemicals that react with these chemical and make them precipitate to aid in the settling process which results in sludge which is continuously removed. Such sludge is toxic and disposal of the sludge has become another major problem.

Industrial waste waters which contain very high levels of BOD and COD (eg distilleries which produce BOD/COD levels as high as 50000 to 100,000 mg/lit) are subjected to another biological process which is the opposite of the aerobic process described above. This is an anaerobic process where oxygen or air is not used and different kinds of microbes work on the contamination. This removes a bulk of the BOD and COD after which the conventional aerobic process is used to remove the remaining levels .A major advantage of the anaerobic process is that it produces methane gas as a by product which can be used to generate power and thus bring down the overall cost of waste water treatment.

Recycling and Re-Use:
The Domestic Scenario: Water supplied to cities and towns by water supply agencies/authorities is treated to make it suitable for drinking. Unfortunately such quality is not required for close to 50% of domestic uses. Domestic uses which result in ?grey water? offers an opportunity for re-cycling. Treating grey water and storing it in a separate set of tanks to be used for flushing toilets can reduce the water demand of a residential unit by 50% . Sewage can also be treated and used for gardening and washing paved areas. These recycling measures will help reduce the load on sewerage systems and sewage treatment plants if widely practiced in cities and towns.

Sewage from cities and towns can be used after primary or secondary treatment for agriculture in nearby farms, gardens, etc. This water is rich in nutrients and makes the use of fertilizers quite unnecessary.(A calculation made in USA some years ago showed that the amount of nutrients discarded yearly in sewage could replace a quantity of fertilser that would require 53 million barrels of oil to make. The cost of this oil at that time was $ 1 Billion !).If municipal waste water were used twice, once for domestic use and again for irrigation, it could boost agricultural production and, what is of prime importance now, it will prevent contamination of lakes, river and even ground water.

The Industrial Scenario: With increasing and stiffer enforcement of pollution control laws, widespread scarcity of raw/fresh water for industrial use, it makes sense for an industry to spend an amount over and above the cost of an effluent treatment plant to further treat it and make it fit for re-use. In many of the states where large industrial estates created by state authorities, and where water is also supplied, the water tariffs are being hiked regularly. Users are finding that the gap between the cost of raw/fresh water per Kilolitre(1000 litres) and that of re-cycled effluent is narrowing and are spending the extra amount required to re-use the treated effluent. In several states, industries who approach the local government for extra land and permission to expand are being asked to sign agreements which require them to reduce existing water consumption levels, agree to drastically reduced quantities of supply for the expansion and in a few cases, agree to a ?Zero discharge? of waste water.

New Technologies:
Whether it is purification of raw/fresh water or effluents, the current trend is to use membrane based processes. Increasing ground water salinity/brackishness of ground water, a premium on space are both leading to the use of this technology which is more efficient than existing treatment systems, such as the biological treatment used for a large majority of sewage and effluent treatment plants.

Reverse Osmosis desalination membranes are used not only for treating brackish raw waters, but also for treating waste water. These systems require only a fraction of the space that a conventional water or waste treatment plant would require.

In the field of waste water treatment, Membrane Bio Reactors (MBR) are the current favourites. The MBR system is a compact waste treatment system that combines biological decomposition with efficient separation of the decomposed matter using the membrane. It makes the installation a far more compact one than a traditional biological system for the same capacity. The MBR system produces far less sludge, better outlet quality and is far less sensitive to fluctuations in pollution loads. It is increasingly being retrofitted to existing systems based on the biological process to increase efficiency and the total output. A considerable amount of work and research continues to find new and cleaner production technologies. When pollution control laws began to be enforced strictly, industries began putting up plants to treat the combined effluent from their manufacturing units and found that investment needed was shockingly higher than they were prepared to spend on what they had so far considered unproductive expenditure. This is the End of Pipe (EOP) solutions approach. Work on evolving cleaner production technologies also worked on waste minimization, segregation of wastes and treating those requiring less treatment separately from highly polluted waste, etc went hand in hand with developing new waste treatment techniques.

Waste Water Quality:
Domestic waste water: By and large sewage anywhere in India would have the following average quality/characteristics:

BOD	200 to 350 mg/lit
COD	500 to 700 mg/lit
Suspended Solids	200 to 300 mg/lit
pH	6.0 to 8.5
Colour	Grey/Brown

The total dissolved solids, hardness, and the other inorganic parameters found in any naturally occurring water would be present in the sewage to the extent they are present in the water that was used to result in the sewage being created.

Industrial waste water:
There are a very wide variety of industries and the waste water generated varies depending on the type of industry that generates it. The BOD and COD in industrial waste waters ranges from ten times the levels in domestic sewage to as much as several hundred times the levels. The

sugar, distillery segment of industry has these types of effluent. The inorganic constituents, such as total dissolved solids, etc also can be many times the levels found in domestic sewage. There is such a variety of waste that it could take several pages of tables to give an idea of the variety.

Whether it is domestic sewage or industrial waste water, the relevant Indian standards for the disposal of the waste are in the following table.

Characteristics	IS-2490 (1974)	IS-3307 (1965)	IS-3306 (1964)	IS-7968 (1970)
pH	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
Solids-total mg/lit	100	-----	600	100
Solids-total dissolved mg/lit	------	2100	------	-----
BOD mg/lit	30	500	500	100
COD mg/lit	250	----	----	250
Oil & grease mg/lit	10	30	100	20

IS-2490 standards apply for waste water discharged into inland surface waters.

IS-3307 standards apply for waste water discharged into land for irrigation.

IS-3306 standards apply for waste water discharged into public sewers.

IS-7968 standards apply for waste water discharged into coastal marine areas.

Policies and Legislative Framework:
Legislation on waste/pollution control took into account not only the generators of waste but also the receiving environments. Limits were laid down in terms of standards for ?effluent? or ?emission?. Depending on the type of waste generator, there were specified limits for volume of waste and characteristics of waste. The minimum protection levels considered necessary for receiving environments of the wastes were also considered. The table above is for four different environments that receive treated wastes and hence the limits seen above.

1. In 1974 the Water (Prevention and control of Pollution) Act was passed by Parliament as the first step to tackle the menace of liquid effluents from Industry. Since water was a state subject requiring states to adopt similar legislation, it took till 1990 for all states to adopt this Act. Boards for the Prevention and Control of Water Pollution were set up in each state to implement the Act and to enforce effluent standards.
2. Effluent standards were drawn on techno-economic grounds called the Minimum National Standards(MINAS).Standards drawn up based on the assimilative capacity of the environment receiving the waste were called Location Specific Standards(LSS).MINAS evolved for different industrial sectors based on work done by the Central Board for the Prevention and Control of Water Pollution in New Delhi.
3. In 1977 the Water(Prevention and Control of Pollution)Cess Act was passed which allowed the various boards to levy a cess on the water abstracted for industrial use or domestic use. This was done to augment the resources of the boards to enable them function effectively.
4. In 1981 the Air(Prevention and Control of Pollution)Act was passed by parliament. This was to be enforced by the various boards. Accordingly, the names of the boards was changed to Pollution Control Boards(PCB).While the Central board became the Central Pollution Control Board(CPCB).The cess has been going up steadily since then.

5. In 1986, the Environment Protection Act(EPA) was passed by parliament. This is a central act implemented by the Ministry of Environment and Forests which delegates powers to state governments to implement the act. Under EPA too a set of effluent and emission standards have been drawn up specific to different industrial sectors. These standards differ from MINA in some aspects/parameters. Under these circumstances, the PCBs usually insist on industries following the stricter of the two standards.
6. Under the EPA the following important sets of rules have been issued:
    a. Manufacture, Use, Import, Export and Storage of Hazardous Micro-Organisms, and Genetically Engineered Organisms or Cells, Rules of 1989.
    b. Manufacture, Storage, and Import of Hazardous Chemicals, Rules of 1989.
    c. Hazardous Waste(Management and Handling) Rules of 1989.
    d. The Public Liability Insurance Act & Rules of 1991.
7. In addition to the above, a notification was issued in 1992 under the EPA requiring a mandatory annual environmental statement by industry.