"Safe Treatment of Domestic Wastewater and Its Percolation to Support Fresh Water Requirement"

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Abstract— Water is the essence of life. No creature on this earth can survive without water. This natural resource is at threat since its being overused then its natural replenishing capacity. This has disturbed natural water cycle. In addition to this municipal wastewater is discharged in the rivers which have made the rivers as sinking drain rather than the elixir of life for the creatures. So there emerges an urgent need that we need to safely treat wastewater. Treatment of wastewater not only helps in the preservation of valuable fresh water resources but also helps to reduce the pollution in environment. This paper discusses about the safe treatment of municipal wastewater for its revisit to the water bodies.

Index Terms— Freshwater, Natural capacity, Pollution, , Reuse, Treated water, Treatment, Wastewater.

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1 Introduction

BASE of human life on earth is water; its importance is next to air for survival. We cannot imagine a day without water. Major water is in the form of oceans 97% (by volume) and remaining 3% of water is fresh. Out of this 3%, 2.997% is in the form of glaciers and only about 0.003% is easily available to us. This is in the form of soil moisture, lakes, streams, water vapor and usable ground water. Fresh water which is available on earth for human use and is very limited and that too is further distributed among the various countries. (Miller, 2000)

Population all over the world is ever-increasing day by day. No nation is untouched by the wind of urbanization that is leading to the rapid migration to urban centers. This is further increasing pressure on the water resource. If we peer at the Indian state of affairs it is anticipated that by 2025 one half will reside in urban centers. Our country India has 2.45% of world surface area; it has 4% of world water resource and 16% of the world population. The total amount of water available from precipitation in a year is about 4000 cubic Km. (Jyothiprakash, 2012)

Our ancestors have been using their old wisdom to manage their water resources depending on their prevailing conditions. In ancient India sanctity of water was a major factor that was helpful to keep water resource safe and preserved. In modern times we have lost all those values and water has turned into a commodity; for modern man it is a one that comes in packaged bottles to satiate ones thirst. Day is not far when a small child will be asked question what are the sources of water the child would say brand names of mineral bottles instead of rainfall, lakes, rivers and ponds. This is alarming to all of us. There is an urgent need that we should use all our resources to save "water resource" that is the elixir of life.

We all use water in our day to day life for various purposes. Wastewater generated from activities as cooking, bathing, washing utensils is the grey water. Whereas wastewater that contains urine, feaces and other biological waste is black water. In India usually the black water is treated onsite in septic tanks and grey water along with rain water and storm water is in the city drains and constitute the household wastewater.

In present scenario in most of the times, this domestic wastewater is collected and then disposed of into the nearby fresh water resources as rivers, lakes and ponds polluting them.

2 Domestic Waste Water

Each day domestic wastewater produced in India's largest cities is more than 38,254 million liters. Of the total wastewater generated in the household 80% is released as greywater. Water uses in a residential building for various activities as per the GRIHA are:

Sl.No.	Domestic Activity	% Of Water Usage
1	Bathing	28
2	Toilet Usage	20
3	Washing Clothes	19
4	Washing Utensils	16
5	House Cleaning	7
6	Drinking	5
7	Cooking	3
8	Other usage	2

Source: GRIHA (2012)

According to the rules of Central Pollution Control Board (CPCB), local body as municipality in a town or city is responsible for collection and treatment of 100 % sewage generated. Out of the total domestic wastewater less than 30 percent is collected, that under goes treatment before it is reverted into freshwater bodies. A bleak reality exits that only a small part

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of sewage generated undergoes treatment, where as a major portion is the one that contaminates the fresh water bodies in various ways. These figures are alarming as these exclude data (unavailable) sewage generated in informal settlements in smaller cities and towns where there exists an acute lack of municipal infrastructure. (India Infrastructure Report, 2011).

2.1 Microbiology of Sewage and Sewage Treatment

There are enormous quantities of microorganisms in the grey water. Count of bacterial in raw sewage is likely to range from 500,000 to 5,000,000 per ml which depends on its time of generation and quantity of water (McGhee, 1991).

Other forms found are viruses, protozoa, worms and other similar forms, presence of which are rarely important and need not to be measured. Bacteria (single celled plants – reproduction by binary fission) are helpful as they can remove soluble, colloidal and solid organic matter from wastewater by the means of extracellular enzymes which soluble food particles outside their cell wall.

Bacteria under the suitable conditions (adequate food , temperature, pH etc.) will reproduce as illustrated in the fig.1

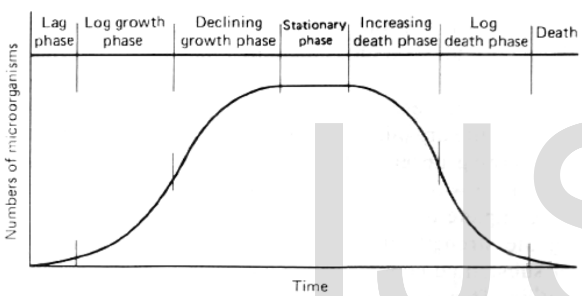

Fig.1: Growth pattern based on number of organisms
Source: McGhee, Water Supply and Sewerage, 1991

"Fig.1" graphically represents relation between the number of organism and time. This shows seven phases in the initial phase food is in abundance and the growth is fast. The end point in the log growth phase and beginning of declining growth phase is the point at which the most part of the available food has been used up, and so food becomes a limiting factor in further growth.

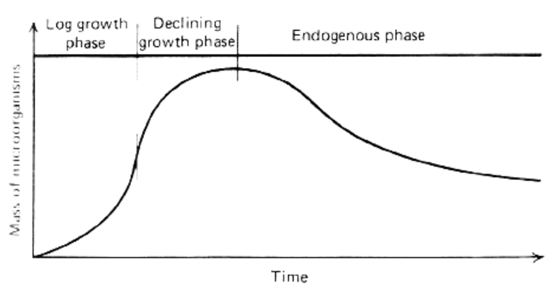

Fig.2: Growth pattern based on mass of organisms
Source: McGhee, Water Supply and Sewerage, 1991

"Fig.2" represents a plot between bacterial mass (and not the bacterial number) versus time. In this curve three phases of growth are shown rather than seven phases.

The beginning of growth is immediate as shown in curve. Log growth phase coincides with the maximum rate of substrate (waste) removal, but this is not the most favorable zone of operation for waste treatment systems. The declining growth phase in general is used for biological treatment systems.

2.2 Natural Way of Waste Water Treatment in Streams

Various forms of life have interdependence on each other, so is in the natural streams where there is a balance between plant life and animal life. There are a variety of species and life forms that thrive in the water of good quality with a natural balance among themselves.

In natural streams there is a balance between plant and animal life, with considerable interdependence among the various life forms. Waters of good quality are characterized by multiplicity of species with no dominance. Bacteria metabolizes the organic matter that enters in the stream, it gets converted into ammonia, nitrates, sulfates, carbon dioxide, etc., these are then used up by plants and algae, and carbohydrates and oxygen is produced. Microscopic animals (like, protozoa, rotifers, etc) obtain their food from plant life. Further insects, worms and fish feed upon these microscopic animals. Bacterial degradation is assisted by some of the animals by feeding on the waste of others. (McGhee, 1991)

Dilution, precipitation, aeration, bacterial oxidation and other such natural processes reduce the concentration of pollutants in a normal cycle and tend to restore the distribution of life forms in the stream in a balanced way. So to treat the wastewater in course of river its natural adaptation capacity is used, this maintains a healthy environment in the stream, without adversely affecting downstream users.

Currently, the introduction of too much of pollutants has disturbed this natural balance in different ways. Different life forms are endangered by the changes in pH, concentration of organic and inorganic compounds. So there rises a urgent need to treat the wastewater before it is discharged into the fresh water bodies.

3.0 Safe Treatment Of Domestic Waste Water

Safe treatment of domestic wastewater is a complex process that includes various physical, chemical and biological methods, which are used to remove contaminants from the wastewater. The various unit operations and processes in various permutations and combinations are used to produce different levels of treatment. These are commonly referred as preliminary, primary secondary and tertiary or advanced treatment of the wastewater. (McGhee, 1991).

Priliminary Treatment	Primary Treatment	Secondary Treatment	Tertiary/ Advanced Treatment
Screening Communition Grit Removal Greese Removal Preaeration Flow Equalization	Sedimentation. Coagulation. Fine screens.	Aerobic system. Aneerobic System.	Adsorption with activated carbon. Ion exchange. Reverse osmosis.

Waste Water Treatment

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3.1 Preliminary Treatment

This is initial treatment that prepares wastewater influent for upcoming treatment. The domestic wastewater not only consist of waste liquid part but also includes large solids (as rags, abrasive grit, sand, metal, etc), odor, grease, and in some cases organic loadings. These are non – supportive contents that would impede operations in the proceeding stages so it needs to be removed at priority. Screening, Comminution, Grit removal, Grease removal, pre-aeration, flow equalization are some of the treatment processes normally used for preliminary treatment. These coarsely clean the wastewater so that it can be proceeded for further treatment.

3.1.1 Screening

It is the most oldest and basic process that is used to separate gross solid material from a liquid. Parallel bars, rods or wires, grating, wire mesh, perforated plates, etc (openings generally circular or rectangular, may be of any shape) are used as screening devices to intercept large floating or suspended material. The material retained (referred as screenings) is disposed off as normally by burial or incineration.

Fig.3: Mechanically cleaned bar screen
Source: (Courtesy Envirex, a Rexnord Company.)
Cited in McGhee, Water Supply and Sewerage, 1991

3.1.2 Comminution

Large floating material in the wastewater is grinded into small parts by the use of comminutors. These are generally installed between the grit chamber and the primary settling tank, it is the position where the handling of screenings would be impractical. Normally rotating or oscillating cutters are used in the comminutors. Screen and cutter used depends on the type and design of comminutors and it may vary.

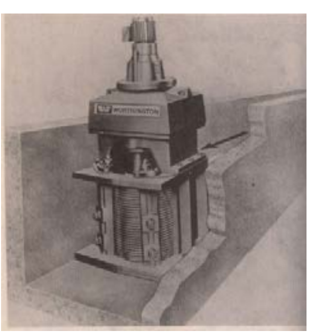


Fig 4: Comminutor
Source: (Courtesy Worthington Pump Corporation.)
Cited in McGhee, Water Supply and Sewerage, 1991

Barminutor is one of type of comminutors that involves a combination of bar screen and rotating cutters

3.1.3 Grit Removal

Inert inorganic materials such as sand, metal fragments, eggshell etc. are many at times found in domestic wastewater. Difference in specific gravity of organic and inorganic solids is the basic principal that is used to remove grit. Excessive wear of machine equipment and blockage of conduits would occur if the grit is not removed.

3.1.4 Grease Removal

Presence of grease in excessive quantities creates problems during biological treatment processes. So these are removed in primary sedimentation tank by surface skimming or by flotation (high concentration) process.

3.1.5 Pre-aeration

As the name suggest, in this process the aeration of wastewater takes place before any treatment is done so as to remove volatile compounds (typically odorous) and increase the dissolved oxygen content. The rate of aeration ranges from 0.01 to 0.05 cubic meter of air per cubic meter of wastewater.

3.1.6 Flow Equalization

Effectiveness of secondary and advanced wastewater treatment is improved by this technique. This technique works by leveling out operation parameters such as flow, pollutant levels and temperature over a period of time and to achieve a near-constant flow rate (reducing downstream effect of above mentioned parameters). Near the head end of the treatment works, before discharging into a water body, and before tertiary or advanced waste treatment operations are some of the locations where this technique of flow equalization may be applied.

3.2 Primary Treatment

After Preliminary treatment of wastewater is done, it is taken to the second stage namely the primary treatment. Sedimentation, chemical coagulation, fine screen are the series of treatment process involved in the primary treatment. This process involves the part removal of suspended solids and organic matter. As a result of primary treatment solids separate out as sludge, which is subsequently treated before ultimate disposal. Organic matter of (high BOD) comes out as a effluent from primary treatment. This process is intended to turn out domestic wastewater suitable for the secondary treatment (biological).

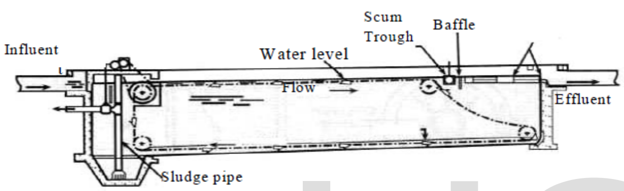
3.2.1 Sedimentation

It is most fundamental unit operation that has been used since ages to clean water. The process works on the basic principle of gravitational settling of heavy suspended in a mixture. The process is useful in grit removal, particulate matter (in the primary settling basin), biological floc (in the activated sludge settling basin),and chemical floc (when the chemical coagulation process is used).

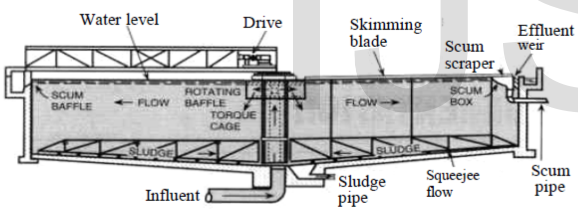
This process of sedimentation takes place in a settling tank, which at times is referred as a clarifier. There are 03 main designs: horizontal flow, solids contact and inclined surface. While designing a sedimentation basin, it is important to bear in mind that the system must produce both a clarified effluent and concentrated sludge. Four types of settling occur, depending on particle concentration: discrete, flocculent, hindered and compression. During the process it is commonly that more than one type of settling to occurs.

(i) **Horizontal flow**

Horizontal-flow clarifiers may be rectangular, square or circular in shape (see figure 5). The flow in rectangular basins is rectilinear and parallel to the long axis of the basin, whereas in centre-feed circular basins, the water flows radially from the centre towards the outer edges. In both types of designs aim is to keep the velocity and flow distributions as uniform as possible in order to prevent currents and eddies from forming, and helping suspended material in settling. Usually basins are made up of RCC or steel. The bottom surface slopes slightly so that sludge removed easily. In rectangular tanks, the slope is towards inlet end, while in circular and square tanks; the bottom is conical and slopes towards centre of the basin.



(a) Parts of a rectangular basin



(b) Parts of circular tank

Fig 5: Settling basin with horizontal flow
Source: Liu and Liptak , Wastewater treatment,

(ii) Solid contact clarifiers

In these there is a suspended layer of sludge at the bottom. Incoming solids come in contact with this and agglomerate and remain trapped within the sludge blanket, as a result water is able to rise upwards while the solids are retained below.

(iii) Inclined surface basins

These are also called high-rate settlers because in these basins settling occurs at high rate. Because of use of inclined trays to divide the depth into shallower sections, thus reducing particle settling times is reduced. A larger surface area is provided by them, so that a smaller-sized clarifier can be used. Many overloaded horizontal flow clarifiers have been upgraded to inclined surface basins. Because of the advantage that, flow is laminar, and there is no wind effect.

3.2.2 Chemical Coagulation

A large portion of suspended particles in water are sufficiently small that their removal in a sedimentation tank is impossible. These are the colloidal particles which as a result of their small size, have a very large surface area to volume ratio. These particles are removed through chemical treatment which involves a series of three unit operations: rapid mixing, flocculation and settling. First, the chemical is added and completely dispersed throughout the wastewater by rapid mixing for 20-30 seconds in a basin with a turbine mixer. Coagulated particles are then brought together via flocculation by mechanically inducing velocity gradients within the liquid. Flocculation takes 15 to 30 minutes in a basin containing turbine or paddle-type mixers. A once-through chemical treatment system is illustrated in figure

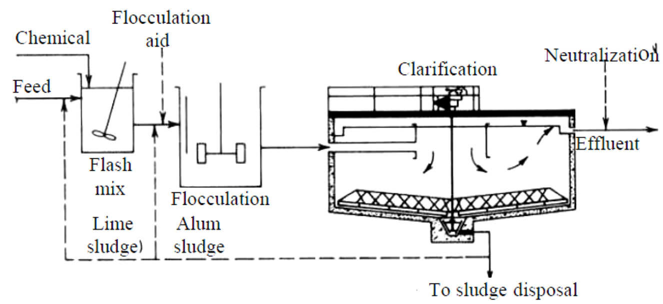


Fig 6 : Chemical Treatment System
Source: Liu and Liptak , Wastewater treatment,1999

The advantages of coagulation include greater removal efficiency, the feasibility of using higher overflow rates, and more consistent performance. On the other hand, coagulation results in a larger mass of primary sludge that is often more difficult to thicken and dewater. It also entails higher operational costs and demands greater attention on the part of the operator. Chemical coagulants that are commonly used in wastewater treatment include alum, ferric chloride, ferric sulfate, ferrous sulfate and lime.

3.2.3 Fine Screens

Fine screens are available in the form of rotating drums and as fixed surfaces. The manner of operation of these devices is somewhat different. In the case of rotating screen a portion of treated water is used to clean the surface of accumulated solids. On the other hand in case of static screen it all depends primarily on gravity and the incoming flow. The Screens serve the purpose of removing solids which may hinder in the upcoming secondary treatment or the biological processes.

3.3 Secondary Treatment

Secondary treatment systems are intended to remove the soluble and colloidal organic matter which remains after primary treatment. This is typically done through biological processes as aerobic systems or anaerobic systems. (Arceivala & Asolekar, 2011)

3.3.1 Aerobic Systems

Aerobic, as the title suggests, means a biological treatment process that occurs in the presence of air (oxygen). It is further subdivided into suspended growth process and attached growth process.

3.3.1.1 Suspended- Growth process

Biological treatment process in which the microorganisms responsible for the conversion of the organic matter or the other constituents in the wastewater to gases and cell tissue are maintained in suspension within the liquid.

3.3.1.1.1 Activated sludge process

It consists of a biological aeration step in which the dissolved organic matter is converted into a settleable form and removed as sludge by settling in a secondary settling tank. This sludge, which has been previously aerated, is referred to as 'activated' sludge; a part of it is recycled back to the aeration tank and the remaining part is withdrawn from the system as excess sludge. This excess sludge and the primary settled sludge are mixed, thickened and sent to a sludge digester for further stabilization followed by dewatering. The treated effluent from the secondary settling tank generally shows an overall BOD removal upwards of 90 percent, which is sufficient, in most cases, to meet river pollution control standards.

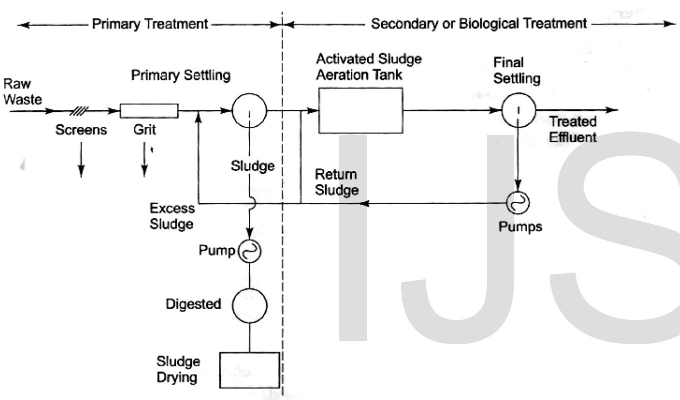


Fig 7: Flow sheet of an activated sludge system
Source: Arceivala & Asolekar, WastwaterTreatment for Pollution Control and Reuse, 2011

3.3.1.1.2 Extended Aeration Process

A modification of the activated sludge process with 'suspended' biological growth. They are found to be easier to construct and operate than the conventional activated sludge plants mainly because there is no primary settling tank and no sludge digester. The raw sewage goes straight to the aeration tank for treatment. The whole process is aerobic. This simplification implies longer aeration time which has earned for it the name 'extended aeration'. The consequent power consumption is, thus, higher but is compensated for by its simplicity in operation. The BOD removal efficiency of the extended aeration process can be higher than that of the activated sludge process, even 97-98 percent, which makes its use especially desirable where it is to be followed by tertiary treatment for reuse (Arceivala, 1981).

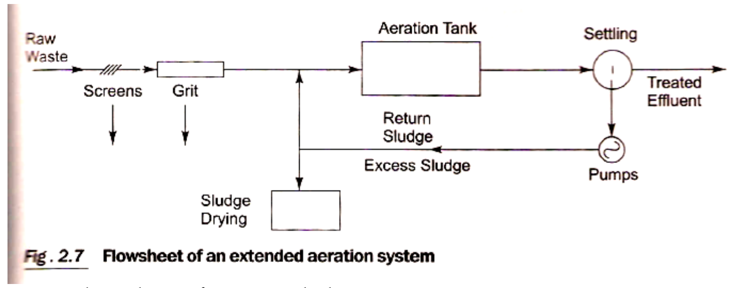


Fig 8: Flow sheet of an extended aeration system
Source: Arceivala & Asolekar, WastwaterTreatment for Pollution Control and Reuse, 2011

3.3.1.1.3 Mechanically Aerated Lagoons

Aerated lagoons fall in between the algal ponds and activated sludge systems. Oxygen is supplied through mechanical or pneumatic aeration. The unit is deeper (3 to 5 m) and hence requires much less land than algal ponds. Their power requirement is almost the same as that for activated sludge but their operation is much simpler.

3.3.1.1.4 Waste Stabilization Ponds

Waste Stabilization Ponds or algal pond, is the simplest method of treatment. The method relies on the use of a shallow pond (1-2 m deep) in which the wastewater is held for several days depending on the temperature and other climatic conditions under which the algae can flourish and, at the same time, provide oxygen through photosynthesis. Algal growth is important for meeting the oxygen demand of the wastewater. The pond area an important since the algal growth depends on the surface area of pond. Relatively large area of land is requirement for this method.

3.3.1.2 Attached–growth process

Biological treatment process in which the microorganisms responsible for the conversion of the organic matter or other constituents in the wastewater to gases and cell tissue are attached to some inert medium, such as rocks, wood, slag, or specially designed ceramic or plastic materials. Attached-growth treatment processes are also known as fixed-film processes.

3.3.1.2.1 Trickling Filters

It consists, normally, of a circular tank with a bed of coarse material as the filter media. The coarse materials normally used are large size rocks, stones or ceramic pieces, slag, etc. The wastewater is usually applied over the bed of supporting media by rotating distribution arms. The effluent is collected in the secondary clarifier, popularly known as humus tank, to separate washed out biomass solids before final disposal of effluent. At present, however, almost all the trickling filters employed in the field use plastic modules of various shapes & sizes as filter media. Biological degradation occurs in a manner similar to that in the activated sludge process except that the filter is a system in which the bio-film is fixed on a solid medium (stone or plastic). Stone media are placed in a bed about 2 meter deep while the wastewater is dosed over it and air is allowed to flow past it within the voids in the media bed.

3.3.1.2.2 Rotating Bio-discs

These are also 'attached' biological growth systems in which biological growth takes place on slowly rotating discs immersed in the wastewater to be treated.

3.3.2 Anaerobic Systems

Anerobic, as the title suggests, means a biological treatment process that occurs in the absence of air (oxygen).

3.3.2.1 Up flow Anaerobic Sludge Blanket (UASB) units

It is like a large septic tank standing on its head. Like the septic tank it needs no power to operate. Yet it is far more efficient in the removal of organics than a septic tank and gives usable biogas. They have been used for many years for high BOD wastes. These units have been seen to be useful for giving inter- mediate levels of treatment of low BOD municipal waste without the need for any power except for initial pumping which is generally needed, in any case, with all treatment methods. The saving in operating power makes the UASB cheaper in terms of overall costs than most other terms in warm countries (with reactor temperatures of more than 20 deg Celsius. However, because of anaerobic nature, there are certain constraints on the inflow and on the effluent, which needs some post-treatment to keep it aerobic. The method is useful for meeting land irrigation requirements economically in a country like India (Arceivala, 1981).

A UASB installation showing screening and grit removal followed by UASB with pumped feed from bottom. The UASB effluent is held for further treatment in a short detention algal pond prior to land irrigation. The sludge goes directly to an open sand bed for drying, the gas goes either to a flare or for use in boilers of a nearby industry.

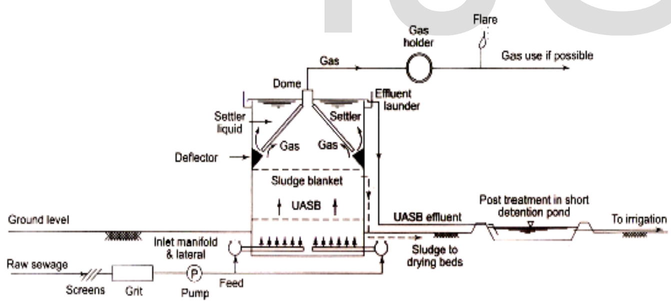


Fig 9: UASB installation showing screening and grit removal followed by UASB with pumped feed from bottom. The UASB effluent is held for further treatment in a short detention algal pond prior to land irrigation. The sludge goes directly to an open sand bed for drying, the gas goes either to a flare or for use in boilers of a nearby industry. Source: Arceivala & Asolekar, WastwaterTreatment for Pollution Control and Reuse, 2011

3.4 Tertiary/ Advanced Wastewater Treatment

Tertiary treatment goes beyond the level of conventional secondary treatment to remove significant amounts of nitrogen, phosphorus, heavy metals, biodegradable organics, bacteria and viruses. In addition to biological nutrient removal processes, unit operations frequently used for this purpose include chemical coagulation, flocculation and sedimentation, followed by filtration and activated carbon. Less frequently used processes include ion exchange and reverse osmosis for specific ion removal or for dissolved solids reduction.

3.4.1 Adsorption with activated carbon -

Adsorption is the process of collecting soluble substances within a solution on a suitable interface. In wastewater treatment, adsorption with activated carbon—a solid interface—usually follows normal biological treatment, and is aimed at removing a portion of the remaining dissolved organic matter. Particulate matter present in the water may also be removed. Activated carbon is produced by heating char to a high temperature and then activating it by exposure to an oxidizing gas at high temperature. The gas develops a porous structure in the char and thus creates a large internal surface area. The activated char can then be separated into various sizes with different adsorption capacities. The two most common types of activated carbon are granular activated carbon (GAC), which has a diameter greater than 0.1 mm, and powdered activated carbon (PAC), which has a diameter of less than 200 mesh.

3.4.2 Ion Exchange

This technique has been used extensively to remove hardness, and iron and manganese salts in drinking water supplies. It has also been used selectively to remove specific impurities and to recover valuable trace metals like chromium, nickel, copper, lead and cadmium from industrial waste discharges. The process takes advantage of the ability of certain natural and synthetic materials to exchange one of their ions.

A number of naturally occurring minerals have ion exchange properties. Among them the notable ones are aluminium silicate minerals, which are called zeolites. In the water softening process, the hardness producing elements such as calcium and magnesium are replaced by sodium ions.

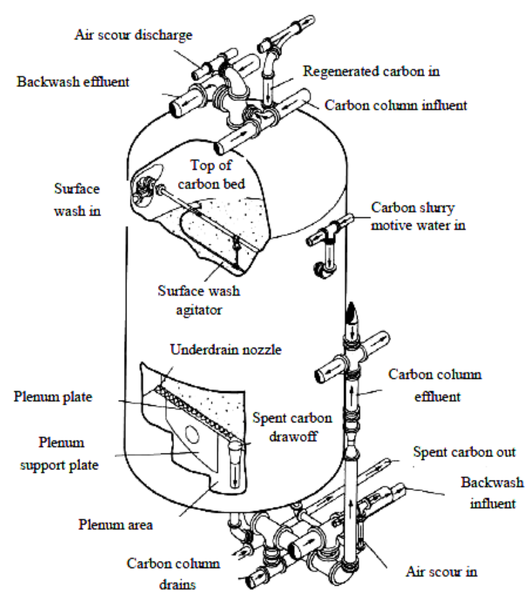


Fig 10: A typical granular activated carbon contactor
Source: Metcalf and Eddy, Wastewater Engineering, 2003.

3.4.3 Reverse Osmosis

In the reverse osmosis process, pure water is produced by forcing water through semi-permeable membranes at high pressure. In ordinary osmosis, if a vessel is divided by a semi-

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permeable membrane (one that is permeable to water but not the dissolved material), and one compartment is filled with water and other with concentrated salt solution, water diffused through the membrane towards the compartment containing salt solution until the difference in water levels on the two sides of the membrane creates a sufficient pressure to counteract the original water flow. The difference in levels represents the osmotic pressure of the solution.

The process can be reversed by applying sufficient pressure to the concentrated solution to overcome the osmotic pressure force the net flow of water through the membrane towards the dilute phase. The solute concentration (impurity) builds up on one side of the membrane while relatively pure water passes through the membrane.

4.0 Percolation Of Treated Water To Enhance Fresh Water

In the present day scenario the lifestyle has changed drastically, we use large amounts of water. The rivers, ponds and ground water get polluted if wastewater comes in its contact, on the contrary if it is treated and then allowed, it increases the amount of water, enhances and supports the fresh water. The method to let the treated water into the percolation for the ground water also helps to increase the water table in that region. So the wastewater when treated acts a boon.

5.0 History Of Wastewater Reuse

The term "wastewater" properly means any water that is no longer wanted, as no further benefits can be derived out of it. About 99 percent of wastewater is water, and only one percent is solid wastes. An understanding of its potential for reuse to overcome shortage of freshwater existed in Minoan civilization in ancient Greece, where indications for utilization of wastewater for agricultural irrigation date back to 5000 years. Sewage farm practices have been recorded in Germany and UK since 16th and 18th centuries, respectively. Irrigation with sewage and other wastewaters has a long history also in China and India. In the more recent history, the introduction of waterborne sewage collection systems during the 19th century, for discharge of wastewater into surface water bodies led to indirect use of sewage and other wastewaters as unintentional potable water supplies. Such unplanned water reuse coupled with inadequate water and wastewater treatment, resulted in catastrophic epidemics of waterborne diseases during 1840s and 50s. However, when the water supply links with these diseases became clear, engineering solutions were implemented that include the development of alternative water sources using reservoirs and aqueduct systems, relocation of water intakes, and water and wastewater treatment systems. Controlled wastewater irrigation has been practiced in sewage farms many countries in Europe, America and Australia since the turn of the current century.

For the last three decades or so, the benefits of promoting wastewater reuse as a means of supplementing water resources and avoidance of environmental degradation have been recognized by national governments. The value of wastewater is becoming increasingly understood in arid and semi-arid countries and many countries are now looking forward to ways of improving and expanding wastewater reuse practices. Research scientists, aware of both benefits and hazards, are evaluating it as one of the options for future water demands.

5.1 Motivational Factors For Recycling/ Reuse

Major among the motivational factors for wastewater recycle/reuse are:

- opportunities to augment limited primary water sources;
- prevention of excessive diversion of water from alternative uses, including the natural environment;
- possibilities to manage in-situ water sources;
- minimization of infrastructure costs, including total treatment and discharge costs;
- reduction and elimination of discharges of wastewater (treated or untreated) into receiving environment;
- scope to overcome political, community and institutional constraints.

Reuse of wastewater can be a supplementary source to existing water sources, especially in arid/ semi-arid climatic regions. Most large-scale reuse schemes are in Israel, South Africa, and arid areas of USA, where alternative sources of water are limited. Even in regions where rainfall is adequate, because of its spatial and temporal variability, water shortages are created. For example, Florida, USA is not a dry area, has limited options for water storage, and suffers from water shortages during dry spells. For this reason wastewater reuse schemes form an important supplement to the water resource of this region.

Costs associated with water supply or wastewater disposal may also make reuse of wastewater an attractive option. Positive influences on treatment costs of wastewater and water supplies, and scopes for reduction in costs of head works and distribution systems, for both water supply and wastewater systems has been the motivation behind many reuse schemes in countries like Japan.

Reuse is frequently practiced as a method of water resources management. For example, depleted aquifers may be "topped-up" by injection of highly treated water, thus restoring aquifer yields or preventing saltwater intrusion (in coastal zones).

Avoidance of environmental problems arising due to discharge of treated/untreated wastewater to the environment is another factor that encourages reuse. While the nutrients in wastewater can assist plant growth when reused for irrigation, their disposal, in extreme cases, is detrimental to ecosystems of the receiving environment. In addition, there may be concerns about the levels of other toxic pollutants in wastewater.

Concern about water supply or environmental pollution may emerge as a political or institutional issue. Community concern about the quality of wastewater disposed to sensitive environments may lead to political pressures on the water industry to treat wastewater to a higher level before discharge, that can be avoided through reuse of wastewater. Institutional structures may also provide incentives for reuse. Because responsibility for different parts of water use and disposal system may rest with different organizations, a water utility may also be faced with standards of service set in agreements with other industry bodies.

5.2 The Example Of Navi Mumbai, India

The following example from Navi Mumbai (New Bombay) a newly developing urban area conceived about 25 years ago to deal with the population overflow of an already crowded Mumbai City, has been growing quite rapidly and experiencing water shortage and other related problems, The population of this area in 1995was 3,25,000persons. In 2001,it was already 7,50,000(excluding a large floating population) and will be yet doubled by 2010. With such a fast growth, a serious strategy for water conservation and reuse has to be thought out by the local body, Navi Mumbai Municipal Corporation (NMMC).

Dagaonkar (2003) who works for NMMC has suggested an overall strategy which would be typically applicable to any fast-growing Indian city. He has suggested the following steps for water conservation and reuse within the area:

1. Metering the water supply of all consumers. This would lead to conservation of water and also reduce somewhat the volume of wastewater to be treated later.
2. Introduction of a Decentralized Wastewater Management system to reduce infrastructure costs and conserve water by groundwater recharge which would also help prevent saline water ingress from creek areas.
3. All existing wastewater treatment plants to be upgraded as necessary to be able to meet State's effluent discharge standards.
4. Wastewater from Navi Mumbai be treated and reused for the following purposes (instead of discharge to the creek):

a	Supply to private consumers for flushing / non-potable purposes	72.0 MLD
b	Supply for greening areas in "corridor" below power-supply cable	18.0
c	For use in various gardens*	3.3
d	For augmenting flow in non-potable lakes**	5.0
e	For aquaculture in existing storm water holding ponds#	upto 1595.0

6.0 Conclusions

The rapid population growth occurring in India, accompanied by an even more rapid migration from rural to urban areas, will only increase as the years go by. It is almost an irrevocable process.

By 2025 one half of India's population is expected to live in urban centers. Our planning and decision-making processes are comparatively slow and, therefore, all our infrastructure and services such as water supply and wastewater disposal are out of step with the growing requirements. Added to this is the problem of our depleting water resources, handled badly and often polluted thoughtlessly.

In a country like India which receives rainfall only for a few months of the year but loses water through evaporation all through the year, rainwater harvesting has to become a way of life for all its people wherever they are located so that rainwater is pushed underground and retained for later use rather than flowing rapidly to the sea and getting lost. In fact, harvesting should not be limited to only rainwater; it could embrace wastewater also. Wastewater should also be considered as an invaluable water resource and harvested, treated and used for enhancing fresh water.

7.0 References

- Arceivala & Asolekar, WastwaterTreatment for Pollution Control and Reuse, 2011, McGraw-Hill, New York.
- India Infrastructure Report, 2011, Govt. of India, New Delhi (India).
- Jefferson.B , Laine. A, Parsons.S, Stephenson.T, &Judd.S, Technologies for domestic wastewater recycling, Urban Water, Vol.1, 1999, Pg. 285- 292.
- Liu, D.H.F. and B.G. Lipták. Wastewater Treatment, 1999, CRC Press, Boca Raton, Florida.
- McGhee, T.J. Water Supply and Sewerage. 1991, McGraw-Hill, New York.
- Metcalf and Eddy, Inc. Wastewater Engineering: Treatment and Reuse, 2003, McGraw-Hill, New York.
- Newman.P & Mouritz.M , 1996 , Principles and planning opportunities for community scale systems of water and waste management , Desalination, Vol.10, 1996, Pg. 339-354.
- United Nations Global Issue, 2011, United Nations, New York.