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Review Article

Review on Control and Purification of Wastes

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ABSTRACT

Waste disposal is almost a daily occurrence and the dimensions are increasing day by day. Apart from all other waste disposals, disposal of containers is every increasing menace. The plastic containers, cartons, bottles and like are becoming an acute problem as plastic is non-degradable. Shores and beaches are littered with such articles. If we add to it domestic and industrial waste disposal into the seas, the problem is of greater magnitude.

Keywords: Domestic waste, industrial waste, control, purification.

INTRODUCTION

Wastes are often divided into two major categories, i.e. domestic and industrial wastes. Domestic wastes include domestic sewage, wastes from processing, detergent and run off from agricultural areas. Industrial wastes include heavy metals, radioactive nuclides, inorganic chemicals and heated water. The extent and several of wastes spewed out by industry is tremendous. To take the American example, every year the US discards 7 million automobiles, 20 million tons of paper, 48 billion bottles and Jars. Much of this material is made of aluminum and Plastic. The mining industry discards more than 3 billion tons of waste rock and mill tailing. According to an official estimate every year, the American lakes, rivers and estuaries receive some 50 trillion gallons of hot water used for cooking by the power industry, and unknown millions of tones of organic and chemical pollutants from cities, plants and industrial plants.

Chlorinated hydrocarbons are other land-based pollutants which have drawn the attention of international community. The chlorinated hydrocarbon pesticides-including DDT, dieldrin and endrin are known to be important pollutants in the marine environment. These pesticides, used extensively for agricultural pest control, enter the marine environment through water runoff from agricultural areas from the atmosphere [1]. It is estimated that nearly half of the pesticides sprayed over agricultural land is carried off by winds into the atmosphere. DDT and its residues have been found in penguin in the Antarctic and in petrels in Bermuda.

This form of marine pollution is quantitatively greater than oil discharge on the sea. Consequently it appears to be more harmful because ocean dumping takes place in and around a region which is vital for the marine eco-system, that is, the neritic epipelagic province [2]. Plankton, the microscopic forms of animal and plant life, which are the basic food upon which higher forms depend, thrive in this very province and damage done to the marine eco-system by the wastes disposed is too much.

Control of Waste Disposal

2(a) **Control at the Source:** Marine pollution on account of waste disposal can be best controlled at source. The first task is surveying the source of pollution. In India, one source of marine pollution is the transmission of waste through the rivers. Other sources of marine pollution need to be found out and control measure should be taken there and then only.

2(b) **Legal Control:** The control of pollution by waste disposal can be controlled by stopping it at the source. In India, the water (control and prevention of Pollution Act) can be an effective instrument. The waste pollution boards, central as well as states, can take effective action. Under the territorial wasters, continental shelf, exclusive economic zone and other maritime zone Act, 1976 the government has sufficient powers to control marine pollution.

The convention of continental shelf recognizes the sovereignty of the coastal states over the continental shelf. It also imposes an obligation on them to keep these areas pollution free. Article 5 runs: the coastal state is obliged to undertake, in the safety zones, all appropriate measures for the protection of living resources of the sea from harmful agents [3,4].

Article 24 of the convention of High Sea authorize states to make regulations to prevent pollution on high seas. Convention on the territorial sea and contiguous zones confers similar power on states.

Another very important convention in this regard is the 1972 London Convention on prevention of Marine Pollution [5]. The 1973 convention for prevention of pollution from ships is another international effort in the same direction. The state parties to the convention are bound not to discharge harmful substance into the seas in order to prevent marine pollution. The European convention on the limitation of the use of certain detergents in washing powder and cleaning products of 1968 and the Oslo convention for the prevention of Marine pollution by dumping from ships and aircrafts of 1972 relate to regional effort to contain and control marine pollution.

To this list international efforts at controlling and preventing marine pollution may be added, the deliberations of the United Nations Committee on peaceful uses of sea-bed and ocean floor beyond the limits of national jurisdiction. This deals with the problem of marine pollution in its various aspects. In 1982 United Nations conference on laws of seas is attempting to down a new regime of Ocean Environment.

Industrial Waste: Available information about industrial solid waste generation in terms of Indian scenario shows that the maximum industrial waste is in form of steel and blast furnace slag which is being generated to the tune of 35 million tons per year. This is followed by Flash from coal based thermal power plants (30 million tons per year). The Planning Commission report estimates that approximately 10-20% of the industrial waste is hazardous waste from chemical industries. In Punjab, about 1145 industries are recognized as hazardous industries. A majority of these are rubber good units, foundries, electroplating units, LPG related units, dyeing and finishing mills chemical plants, solvent extraction plants, tanneries, etc. it is estimated that the industrial waste being generated in Punjab per year amounts to 2.9 million tons per year (including 1.8 million tones of fly ash from coal based thermal power plants). Disposal of industrial waste is also not proper and is a cause of concern.

Self-Purification of Natural Systems: Before human activity increased the amount of Pollutants, natural water systems were able to remove of the natural existing Pollutants. But it is nowadays observed that none of the natural waters so available are absolutely fit for Potable use. It is, therefore, necessary to subject any type of water to certain suitable Processes of purification rendering it safe for human consumption, pleasing to the senses and suitable for ordinary domestic and industrial uses. The objectives to be achieved through Purification of water are as follows:

(a) Removal of all pathogenic contained in untreated water.
(b) Freedom from unpleasant taste and odour.
(c) Freedom from murkiness or objectionable color and having good appearance.
(d) Suitability for domestic purpose viz cooking, washing etc. and for industrial purpose viz brewing dyeing etc.
(e) Reduction of the corrosive and tuberculating properties of water which affect the carrying capacity and life of the pipe-conduits.

The self- purification mechanisms of natural water systems include physical chemical and biological processes. The speed and completeness with which these processes occur depend on many variables that are system-specific. Hydraulic characteristics such as volume, rate and turbulence of flow, physical characteristic of bottom and bank material variations in sunlight and temperature as well as chemical nature of the water, are all system variable that have an influence on the natural purification processes in natural waters, these systems variable are set by nature and can be altered.

The same physical, chemical and biological processes that serve to purify natural water system also work in engineered system. In water and waste water treatment plants, the rate and extent of these Processes are managed by controlling the system variables. The self-purification of natural water system is discussed below:

Physical processes

The major physical processes involved in self-purification of water courses are dilution, sedimentation and re-suspension, filtration, gas transfer and heat transfer. These processes are not only important but are also of significance in their relation to certain chemical and biochemical self-purification processes.

Dilution: In the beginning of twentieth century, wastewater disposal practices were based on the premise that "*the solution to pollution is dilution*". Dilution was considered as the most economical means of waste water disposal. In this method, relatively small quantities of waste are discharged into large bodies of water.

Although dilution is a powerful adjunct to self-cleaning mechanism of surface water, its success depends upon discharging relatively small quantities of waste into bodies of water. Growth in population and industrial activity, with increases in water demand waste water quantities, precludes the use of many streams for dilution of raw or poorly treated waste waters.

Sedimentation and Re-suspension: Sources of suspended solids, one of the mast common water pollutants, include domestic and industrial wastewater and runoff agricultural or urban activities, these solids may be inorganic or organic materials and/or live organisms, and they nay very in size from organic particles to tiny, almost invisible, colloids. In suspension, solids turbidity and the reduced light penetration may restrict the photosynthetic activity of plants inhibit the vision of aquatic animals , interfere with feeding of aquatic animals that obtain food by filtration, and be abrasive to respiratory structures such as gill of fish[6].

Setting out or sedimentation, is nature's method removing suspended particles from a watercourse, and most large solids will settle out readily in quiescent water. Particles in the colloidal size range can stay un-suspension for long periods of time, though eventually mast of these will also settle out.

Re-suspension of solids is common in times of flooding or heavy runoff. In such cases, increased turbulence may resuspend solids formerly deposited along normally quiescent areas of a stream and carry them for considerable distances downstream. Eventually they will again settle out, but not before their presence has increased the turbidity of the waters unto which they have been introduced.

Filtration: As large bits of debris wash along a stream bed, they often lodge on reeds or stones where they remain caught until wash them the mainstream again. Small bits of organic matter or inorganic clays and other sediments may be filtered out by pebbles or rocks along the stream bed. As water percolates from the surface downward into ground water aquifers, filtration of a much more sophisticated type occur, and if the soil layers are deep and fine enough, removal of suspended material is essentially complete by the time water enters the aquifer. Many streams interchange freely with the alluvial aquifer underneath them, so the filtered water may re-enter the stream at some point downstream [7,8,9].

Gas Transfer: The transfer of gases of into and out of water is an important part of the natural purification process. The replenishment of oxygen of lost to bacterial degradation of organic waste is accomplished by the transfer of oxygen from the air into the water. Conversely, gases evolved in the water by chemical and biological processes may be transferred from the water to the atmosphere.

Chemical Processes: Natural water courses contain many dissolved minerals and gases that interact chemically with one another in complex and varied ways. Oxidation, reduction, dissolution-precipitation and other chemical conversion may alternately aid or abstract natural purification of natural water systems [10].

Biological Processes: Many of the chemical reactions involved in the self purification process must be biologically mediated, these chemicals reactions are not spontaneous but require an external source of energy for initiation, In the case of bridgeable organics and other nutrients, this activation energy can be supplied by micro-organisms that utilize these materials for food and energy, The sum total of the processes by which living organisms assimilate and use food for subsistence, growth and reproduction is called metabolism, The metabolic processes and the organisms involved are a vital part of the self purification process of natural water systems.

Organisms of significance in natural purification are bacteria, algae and protozoa. The metabolic processes of the micro-organisms convert the biodegradable organics (discharged through waste effluents) into biological end products at the cost of the dissolved oxygen of the water body.

Other Aquatic Organisms: In the presence of sunlight, different spices of algae metabolize the inorganic compounds and give off oxygen as a waste product which infect replenishes the dissolved oxygen content of the water body (D.C. level is reduced by water pollutants). Lower order animals like rectifiers and crustacean prey upon protozoan, bacteria and algae and thereby maintain the balance in the populations of primary producers.

The cooling of the water at night, the disinfection of the water by sunlight and the pushing ashore of the pollutants by wind are all examples of self- cleaning processes of nature which successfully purified the water bodies before human activity increased the quantity of the pollutants contaminating the water bodies.

Control Measures of Water Pollution (Waste Water Treatment): Wastewaters, whether domestic or industrial have several undesirable components - organic and inorganic pollutants that are potentially harmful to the environment and human health. The treatment of waste water and its proper management has become a necessity in order to conserve this vital resource. The main aim of waste water treatment is the removal of contaminants from water so that the treated water can be reused for beneficial purposes. The waste water treatment is carried out in three stages - ro, aru. Secpmdaru and Tertoaru pr advanced waste treatment.

Primary Treatment

Wastewater contains a wide variety of solids of various shapes, sizes and densities. The primary treatment is of general nature and is used for removing suspended solids, odor, colour and to neutralize the high or low pH in the case of industrial effluents. This stage exploits the physical or chemical properties of the contaminants and removes the suspended and floating matter by screening, sedimentation, floatation, filtration, precipitation etc.

Screening: Screening devices are used to remove coarse solids from waste water. Coarse solids consist of sticks, rags, boards and other large objects that often and, inexplicably, find their way into waste water collection systems. Because the primaries purpose of screens it o protect pumps and other mechanical equipment and to prevent clogging of valves and other appurtenances in the waste water plant, screening is normally the first operation performed on the incoming wastewater.

Waste Water screens are classified as fine or coarse, depending on their construction. Coarse screens usually consist of Vertical bars spaced 20- 60 mm apart and inclined away from the incoming flow. Solids retained by the bars are usually removed by manual raking in small plants, while mechanically cleaned units are used in larger plants. Fine screening (10-20 mm) consist of woven wire cloth or perforated plates mounted on a rotating disk or drum partially submerged in the flow, or on a traveling belt. Fine screens should be mechanically cleaned on a continual basis.

The quantity of solids removed by screening depends on screen- opening size. Screened solids are coated with organic material of a very objectionable nature and should be promptly disposed of to prevent a health hazard and/or nuisance condition. Disposal in a sanitary land fill, grinding and returning to the waste water flow, and incineration are the most common disposal practices.

Comminuting: As motioned above screenings are sometimes shredded and returned to the waste water flow. A hammer mill device is most often used for this purpose. More often, a shredding device called a comminutor is located across the flow path and intercepts the coarse solids and shreds them to approx. 8 mm in size. These solids remain in the waste water.

Many kinds of comminutors are available. Basic parts include a screen and cutting teeth. The screen may be a slotted drum that rotates in the vertical plane. Stationary teeth then shred material that is intercepted by the screen. Other types use a stationary semicircular screen and rotating or oscillating cutting teeth. Another device, called a barminutor, uses a vertical bar screen with a cutting head that travels up and down the rack of bars, shredding the intercepted material.

Shredding devices should be located ahead of pumping facilities at the treatment plant. Grit removal ahead of the shredder will save wear on the cutting head. Usually, however, grit chambers are located at or above ground level to facilitate grit handling, and pumps may be necessary to lift the sewage to them. In this case, shredding is done ahead of the pumps and cutter wear must be tolerated.

Grit Removal: Municipal waste water contains a wide assortment of inorganic solids such as pebbles, sand, silt, egg shells, glass and metal fragments. Operations to remove these inorganics will also remove some of the larger, heavier organics such as bone chips, seeds etc. Together, these comprise the material known as grit in wastewater treatment systems. Most of the substances in grit are abrasive in nature and will cause accelerated wear on pumps and sludge handling equipment with which it comes in contact. Grit deposits in areas of low hydraulic shear in pipes, sumps and clarifiers may absorb grease and solidify, also, these materials are not biodegradable and occupy valuable space in sludge digesters. it is, therefore, desirable to separate them from the organic suspended solids, the latter should not be allowed to settle otherwise it gets entangled with the inorganic matter causing septicity of waste water and requiring unnecessary labor and expense for removal. A velocity of flow between 0.15 to 0.3 $rn.sec^{-1}$ is practically considered sufficient for this purpose.

Grit removal facilities basically consist of an enlarged channel area where reduced flow velocities allow grit to settle out. Many configurations of grit tanks are available. At least two separate chambers should be provided, one to take care of low flow and the other for the high flow. A period of detention of 1 min is commonly employed. Grit chambers are cleaned by hand, mechanically or hydraulically, hand cleaning is done only in the case of smaller plants, is less hygienic and odor free though somewhat easier for disposing off the removed material than in the case of mechanical cleaning. In hydraulic-cleaning, the deposited materials are flushed us under fire-stream directed from a central point and removed through pipes in the side-walls or bottom of the chamber.

First larger treatment plants, this trend is towards aerated grit chamber. Turbulence created by the injection of compressed air keeps lighter organic material in suspension while the heavier grit falls to the bottom. Aerated grit chambers may serve another useful purpose. If the sewage is anaerobic when it arrives at the plant, aeration serves to strip noxious gases from the liquid and to restore it immediately to an anaerobic condition, which allows for better treatment when an aerated grit chamber is used for this purpose. The aeration period is usually extended from 15 to 20 min.

Grit particularly from channel-type grit chamber, may contain a sizeable fraction of biodegradable organics that must be removed by washing or must be disposed of quickly to avoid nuisance problems. Grit containing organics must either be placed in a sanitary landfill or incinerated, along with screenings, to a sterile ash for disposal.

Skimming Tanks: A skimming tank is a chamber so arranged that the floating matter like oil, fat grease etc. rise and remain on the surface of the waste water (Sewage) until removed, while the liquid flows our continuously under partitions or baffles. It is necessary to remove the floating matter from sewage otherwise it may appear in the form of unsightly scum of the surface of the settling tanks or interfere with the activated sludge process of sewage treatment. It is mostly present in the industrial sewage. In ordinary sanitary sewage, its amount is usually too small.

The chamber is a long trough shaped structure divided up into two or three lateral compartments by vertical baffle walls having slots for a short distance below the sewage surface and permitting oil and grease to escape into stilling compartments. The rise of floating matter is brought about the blowing air into the sewage from diffusers placed in the bottom. Sewage enters the tank from one end, flows longitudinally and leaves out through a narrow-inclined duct. A theoretical detention period of 3 min is enough. The floating matter can be either hand or mechanically removed.

Grease traps are in reality small skimming tanks designed with submerged inlet and bottom outlet. The traps must have sufficient capacity to permit the sewage to cool and grease to separate. Frequent cleaning through removal covers is essential for satisfactory operation. Grease traps are commonly employed in case of industries, garages, hotels and hospitals.

Sedimentation: In this step, the settleable solids are removed by gravitational setting under quiescent conditions. The sludge formed at the bottom of the tank is removed as under flow either by vacuum suction or by taking it to a discharge point at the bottom of the tank for withdrawal. The clear liquid produced is known as the overflow and it should contain no readily settleable matter.

The sedimentation operation in waste treatment applications may be carried out in rectangular horizontal flow, circular radial flow, or vertical flow basis. The three main types of arrangements. In rectangular tanks, feed is introduced at one end along with the width of the tank and the overflow is collected at the surface either across the other end or at different points along the length of the tank. An endless conveyor scrapes the floating material into a screen through which it also pushes the settled solids into a sludge hopper.

In the circular radial flow tanks, the feed is introduced through a centre wall and the clarification effluent is collected at weirs along the periphery of the tank. Sludge removal is affected by means of a rotary sludge scraper which forces the settled sludge down a slopping bottom into a central hopper, from which it is withdrawn. Scum is removed by a surface skimming board which is attached to the rotary mechanism and positioned in such a manner that the scum can be collected into a trough situated at the surface.

Vertical flow tanks are often used in small treatment plants where the feed is applied at the point or points along the bottom, and clarified affluent is collected at the top. A sludge blanket is maintained in the lower part of the tank through which the suspension rises. It is important to control the sludge withdrawal and bleed carefully to avoid losing the blanket, which acts as a filter for small particles.

Flotation: Flotation may be used in place of sedimentation, primarily for treating industrial waste wasters containing finely divided suspended solids and oily matter. Floating technique is used in paper industry to recover fine fibers from the screened effluent and in the oil industry for the clarification of oil-bearing waste. It is also used for treating effluents from tanneries, metal finishing, cold rolling and pharmaceutical industries.

Particles of density very close to that of water are very difficult to settle in normal sedimentation tanks and take a long time for separation. In such cases, the separation can be speeded up by aerating the effluent whereby air bubbles are attached to the suspended matter. This has the effect of increasing the buoyancy of the particles; as a result, the particles float to surface from where they can be readily removed. To aid in the flotation process, chemical coagulants such as aluminum and ferric salts or polymer coagulant-aids are often used. These chemicals increase the flocculants structure of the floated particles so that they can easily entrap the air bubbles.

Two methods of flotation are currently available: (1) dispersed-air flotation and (2) dissolved air flotation. In dispersed-air floatation, air is introduced directly into the liquid through a revolving impeller or through diffusers. The air bubbles generated in dispersed air flotation system are normally about 1 mm in diameter and they usually cause turbulence which breaks up fragile flock particles. Due to this, dispersed air flotation is not a favored technique in the treatment of municipal wastewater, although it finds a limited application in treating industrial wastes containing oil, grease and fine powders.

In dissolved-air flotation, air is intimately brought into contact with the waste water at a pressure of several atmospheres when air is dissolved. The pressure on the liquid is reduced to atmospheric level through a back-pressure valve, thereby releasing micron-sized bubbles suspended solids and oil are carried to the surface of the flotation tank by these minute air bubbles. In a typical flotation, the entire flow is pressurized and held in the retention tank so that the air gets dissolved in the liquid.

The intense mixing of air and wastewater in the pressurization system often degrades flocculent suspensions or oil emulsions following chemical treatment. A portion of the clear effluent is recycled for pressurization to prevent such degradations. Compressed air is introduced into the discharge of the recycle pump and intimate contact is achieved in the retention tank. The recycled flow is then returned through a back-pressure valve (where the pressurized air is released and mixed with the influent for floatation. The time in the flotation tank is about half an hour.

Neutralization: When pH of the industrial waste is too high or too low then it should be neutralized by acid or alkali and only neutral effluent should be discharged into the drain or public sewer. For neutralization of the acidic effluent, the following techniques are used:

1. Lime Stone Treatment: For acidic effluents, lime stone can be used as it will form calcium compounds depending upon the presence and amount of acid.
2. Caustic Soda Treatment: Although costly, yet the method is also utilized for neurtilizaing the acid, Caustic soda is added in the influent to make the pH neutral. Only small amount of caustic soda is needed for this work. For neutralization of alkaline effluent, the following techniques are follows:
   (a) Carbon Dioxide Treatment: If the industry is producing carbon dioxide then only this method should be utilized for neutralizing the pH otherwise it would be costly affair. Here carbon dioxide is passed in alkaline effluent to make its pH almost 7 i.e. neutral value.
   (b) Sulphuric Acid Treatment: This is a common method of neutralizing alkaline effluent. Here sulphuric acid is added in the effluent till pH become almost?
   (c) Utilizing Waste Boiler-flue Glass: The stack gas which contains about 12 percent carbon dioxide is utilized to react alkaline effluent to make it neutral.

Secondary or Biological Treatment: The biological process of sewage is a secondary treatment involving removing, stabilizing and rendering harmless very fine suspended matter, and solids of stabilizing the wastewater that remain event after the primary treatment has been done. Since much of the organic material in wastewater may be colloidal or dissolved, the primary treatment processes are largely ineffective in removing it. The organic matter still represents a high demand for oxygen which must be reduced further so that the effluent may be rendered suitable for discharge into the water bodies.

In biological treatment, oxygen supplied to the bacteria is consumed under controlled conditions so that most of the BOD is removed in the treatment plant rather than in the water course. Thus, the principal requirements of a biological waste treatment process are an adequate amount of bacteria that feed on the organic material present in wastewater, oxygen and some means of achieving contact between the bacteria and the organics.

Two of the most commonly used systems for biological waste treatment are the activated sludge system and biological film system. In the activated sludge system, the wastewater is brought into contact with a diverse group of micro-organisms in the form of a flocculent suspension in an aerated tank, whereas in the biological film system, also known as trickling filters, the wastewater is brought into contact with a mixed microbial population in the form of a film of slime attached to the surface of a solid support system. In both cases the organic matter is metabolized to more stable inorganic forms.

Activated Sludge Process: The essential features of activated sludge process are: an aeration stage, solids-liquid separation following aeration, and sludge recycle system. Wastewater after primary treatment enters an aeration tank where the organic matter is brought into intimate contact with the sludge from the secondary clarifier. This sludge is heavily laden with microorganisms which are in an active state of growth. Air is introduced into the tank either in the form of bubbles through diffusers or by surface aerators. The micro-organisms utilize the oxygen in the air and convert the organic matter into stabilized, low-energy compounds such as NO_2, SO_4, CO_2 and synthesize new bacterial cells. The effluent from the aeration tank containing the flocculent microbial mass, known as sludge, is separated in a setting tank, sometimes called a secondary settler or a clarifier. In the settling tank the separated sludge exists without contract with the organic matter and becomes activated. A portion of the activated sludge is recycled to the aeration tank as a seed; the rest is wasted. If all the activated sludge is recycled, then the bacterial mass would keep increasing to the stage where the system gets clogged with solids. It is, therefore, necessary to ‘waste’ some of the micro organisms, and this wasted sludge is the one which is processed.

Trickling Filters: The secondly commonly used biological waste treatment process is the trickling filter method. Trickling filters are also called percolating filters. It has good adaptability to handle peak shock loads and the ability to function satisfactorily after a short period of time. Milk processing, paper mill and pharmaceutical wastes are among those treated by tricking filters conventional trickling filters normally consist of a rock bed, 1 to 3 meters in depth, with enough openings between rocks to allow air to circulate easily. As the liquid trickles over the packing, oxygen and the dissolved organic matter diffuse into the film to be metabolized by the micro-organisms in this slime layer end products such as NO_3, CO_2 etc. diffuse back out of the film and appear in the filter effluent.

As the micro-organisms utilize the organic matter, the thickness of the slime film increases to a point where it can no longer be supported on the solid media and gets detached from the surface. This process is known as sloughing. A settling tank following the trickling filter removes the detached bacteria film and some suspended matter.

Handling and disposal of sludge from biological wastewater treatment plants is an important problem and represents about half the cost of most sewage treatment plants. The concentration of solids in the primary sewage sludge is about 5 percent; the activate sludge contains less than 1 percent solids; ad sludge from trickling filters has about 2 percent solids. The common unit operations of sludge treatment and disposal involve concentration or thickening, digestion, conditioning, dewatering, oxidation and safe disposal.

Tertiary or Advanced Wastewater Treatment: Usually the primary and secondary treatments are sufficient to meet wastewater effluent standards. However, if water produced is required to be higher water quality standards (in case the water to be put to some direct reuse) then advanced wastewater treatment is carried out.

A wide variety of methods are used in advanced waste treatment, which include the removal of (a) Suspended solids, (b) BOD, (c) Plant nutrients, (d) Dissolved solids and (e) toxic substances. These methods may be introduced at any stage of the total treatment process as in the case of industrial wastewaters or may be used for complete removal of pollutants after the secondary treatment.

The wastewater treatment processes are basically concentrating or thickening processes on which the suspended solids are removed as sledges. The impurities are the bulk liquid. This concentrated form if referred to as sludge whereas the dissolved solids are first converted into suspended solids which are subsequently removed as sledges.

In addition, the following measures can be taken to control water pollution:

(1) **Thermal Pollution:** For minimizing thermal pollution, hot water should be cooled before release from factories, and removal of forest canopies and irrigation return flows should be prohibited.

(2) **Prohibition:** Besides reserving separate water supplies for livestock, the following prohibition should be enforced to avoid contamination of the main sources of drinking water.

(a) Bathing and washing of clothes in rivers and streams.

(b) Discharging untreated or treated domestic, commercial and industrial sewage in water bodies.

(3) **Judicious Use:** Pesticides (preferably less stable) and fertilizers should be very judiciously used to avoid chemical pollution of water through agricultural farm run-offs.

(4) **Reuse of Water:** The treated wastewater can be reused for several purposes, for instance:

(a) Treated water can be reused for recreation purposes like fishing and boating.

(b) Treated water can be reused as industrial water supply.

(c) Reclaimed wastewater can be used for irrigation or municipal purposes.

(d) Related water can be reused for cooling processes in thermal plants.

(e) In areas of acute water scarcity, wastewater treated to the highest standards can be reused as potable water (provided there is public acceptance for wastewater use).

(5) **Legislation:** For effective control of water pollution, legal provisions regarding water pollution should be enforced by special administrative machinery comprising of highly and experienced personnel.

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