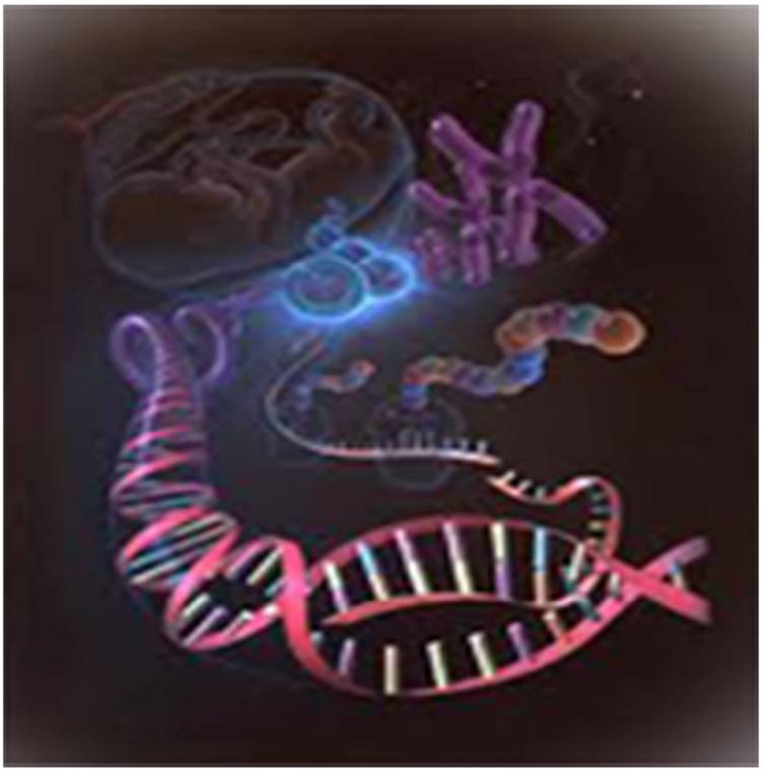
IJLBPR

ISSN 2250 - 3137
Vo1. I, No.1, January 2012

International Journal of
Life Sciences Biotechnology and Pharma Research



International Journal of Life Sciences Biotechnology and Pharma Research
Hyderabad, INDIA

www.ijlbpr.com

Email : editorijlbpr@gmail.com or editor@ijlbpr.com

International Journal of Life Sciences Biotechnology and Pharma Research

ISSN 2250-3137 www.ijlbpr.com
Vol.1, Issue. 1, January 2012

Research Paper

PERFORMANCE STUDIES ON A PHARMACEUTICAL WASTEWATER TREATMENT PLANT WITH A SPECIAL REFERENCE TO TOTAL DISSOLVED SOLIDS REMOVAL

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Every community produces both liquid and solid wastes. From the stand point of sources of generation wastewater may be defined as a combination of the liquid or water carried waste removed from institutions, residences, commercial and industrial establishments. The ultimate disposal of wastewater can only be onto the land or into the water. But whenever the water courses are used for the ultimate disposal, the wastewater is given a treatment to prevent any injury to the aquatic life in the receiving water. Normally the treatment consists of removal of suspended and dissolved solids through different units of ETP. Experiments were conducted with different sizes of activated carbon for TDS removal. Activated carbon plays a major role for TDS removal. Reduction in the size of activated carbon increases the efficiency to reduce TDS that is due to the increased surface area. But very fine activated carbon is of no use as no proper packing can be done and it will have more particle space and hence dissolved solids easily pass through the spaces. Hence the size plays a major role for TDS removal and proper back washing of filters is also important.

Keywords: Total Dissolved Solids (TDS), Effluent Treatment Plant (ETP), Waste water, Activated Carbon.

INTRODUCTION

Industries receive large amount of water for their process but only small fraction of it is incorporated in their products and most by evaporation. The rest finds its way in to the water courses as wastewater. If this untreated industrial wastewater is allowed to accumulate; it causes the decomposition of the organic material thus leading to the production of large quantities of harmful gases. In addition to which certain industrial waste contain pathogenic microorganisms and toxic compounds which have their own adverse affects, where certain industrial effluents also contain nutrients that stimulate the growth of aquatic flora and fauna.

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For these reasons the immediate and nuisance free removal of wastewater from its source of generation followed by treatment and disposal is not only deferrable but is necessary in an industrialized society. The trade waste has to be treated in varying degree according to whether it is discharged into a sewer or a land or water course.

Waste discharged into sewers generally need to be treated only to such an extent as to ensure that they are not harmful to the structure of the sewer, not liable to react with sewage causing deposition of sediment, that they will not cause organic growth in the sewers, they will not interfere with the process of sewage treatment. Waste discharged to land or water courses must be purified to meet the normal standards applicable to sewage effluents and they must also be non- poisonous.

CHARACTERISTICS OF WASTEWATER

The characterization of the raw wastewater is essential in the planning for effective and economical methods of water pollution control. Due to the varying nature of the industrial wastes, many of the recent installations have designed their treatment units with due consideration to the raw wastewater characteristics, and the effluent characteristics, as established by the Indian Standards Institution (ISI), State Pollution Control Boards (SPCB), or by the local administrative authorities. But the characterization of the municipal wastewater prior to a treatment plant design have not received the attention it deserves, probably because of its lower pollution potential compared to that of industrial wastes.

The characteristics of the municipal wastewater vary from place to place and depend on various factors like economic status and food habits of the community, water supply position and the weather condition of the locality. The characteristics of the waste from an Indian city may not be similar to that from a city in the USA.

Characterization of wastewater is done to determine the physical, chemical and biological characteristics and also to decide about the means to reduce the pollutant concentrations.

Wastewater is characterized as follows:

1. Physical Characteristics.
2. Chemical Characteristics.
3. Biological Characteristics.

SOURCES OF WASTEWATER IN A PHARMACEUTICAL INDUSTRY

The wastewater in any industry comes from the different processes taking place in the industry and this can be called as “process wastewater”. Process wastewater can be defined as any water which during manufacturing or processing comes into direct contact with or results from the production or use of any raw material, intermediate product, finished product, by product or waste product. Wastewater from the pharmaceutical industries are characterized to have a high BOD, COD, TDS, TSS concentrations and extremely variable pH values ranging from 4 to 11.

Water is used and wastewater is generated in pharmaceutical manufacturing process as follows:

1. Water of reaction: Water formed during the chemical reactions.

2. Process stream water: Water added to the carrier, spent acid or spent base, which has been separated from the reactor mixture in order to purify the stream by washing away the impurities.

3. Product washes: Water added to the reaction medium to purify to purify an intermediate or final product by washing away the impurities.

4. Process solvent water: Water used to transport or support the chemicals involved in the reaction process, this water is usually removed from the process through a separation sludge, such as drying, centrifugation and decantation.

5. Condensed steam: Steam is used as a sterilizing medium and in steam strippers for solvent recovery and wastewater treatment.

In addition to process wastewater, other types of wastewater may be generated during pharmaceutical manufacturing:

1. Equipment's and floor washes.
2. Pump seal water.
3. Cooling water.
4. Bottle washing.
5. Sanitary wastewater.

MATERIALS AND METHODS

Pilot Plant Studies

The pilot plant is a prototype of ETP as shown in Figure 1. It is a lab scale experimental model of ETP. Proper monitoring of parameters can be performed in the pilot plant.

Pilot plant comprised of the following:

1. Storage tank.
2. Screens.
3. Collection tank.
4. Aeration tank.
5. Clarifier.
6. MGF(Multi Grade Filter).
7. ACF (Activated Carbon Filter).
8. Final Tank

Description of Each Unit of Pilot PLANT

Storage Tank: The storage tank is of 2 feet in Depth, 1 feet in Length and 1 feet in Breadth. The effluent is collected from the existing ETP and about 5 liters of effluent is stored in the storage tank.

Screens: From the storage tank the effluent passes through the screens; where the floating bigger particles are removed.

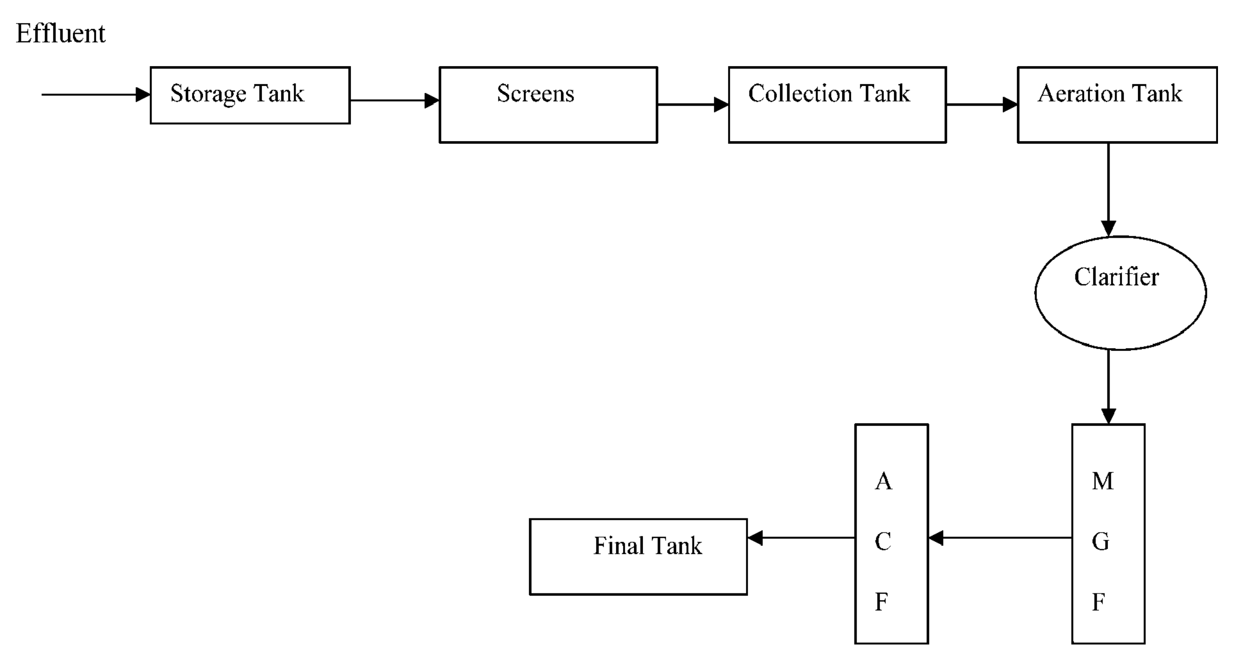
Collection Tank: The dimensions of the collection tank are 5 inches Depth, 1 feet Length and 2 feet Breadth. The floating particles free effluent is collected into the collection tank. The overflow from the collection tank flows into the equalization tank where polyelectrolyte is added and mixed properly so that homogenized mixture of effluent is obtained.

Aeration Tank: The aeration tank is of 1 feet in Depth and 8 inches in Diameter. The effluent then reaches to the aeration tank where the effluent is aerated. DAP and urea are added in the tank; so as to maintain the MLSS.

Clarifier: The Depth of the clarifier is 1 feet with 8 inches Diameter**.** The aerated effluent is next passed through the clarifier where a detention period of 8 hours is provided and the sludge formed is recycled back into the aeration tank.

Filters: The MGF was made by a container of 9 inches Depth and 8 inches Diameter and the ACF was also made by a container of 9 inches Depth and 8 inches Diameter. The overflow of the clarifier passes through the sand filters and then

Figure 1: Flowchart of Pilot Plant



through the activated carbon filters.

Final Tank: The final tank is of 5 inches Depth, 5 inches Length and 5 inches Breadth. The treated water is collected in the final tank.

Design Criteria

1. Flow Rate: The flow rate is regulated to 86 KL per day with the help of regulators fixed in the pipes. Maintaining the flow rate gives a efficient treatment.

2. Detention period: Detention period is provided for settling of flocs in collection tank and for the better formation of sludge in the clarifier.

3. MLSS: In the ratio 1:10 DAP and urea are added in the aeration tank for maintaining MLSS in the tank. Reduction of foam formation in the aeration tank is done by adding castor oil.

Monitoring of Pilot Plant

The pilot plant monitoring was carried out for a period of 15 days. During this period the following parameters were considered:

1. pH.
2. TDS(Total Dissolved Solids).
3. BOD(Biochemical Oxygen Demand).
4. COD(Chemical Oxygen Demand).

The pilot plant analysis was carried out. Mainly four parameters were considered namely pH, TDS, COD, and BOD. All these parameters help us to know the efficiency of Pilot plant. The Pilot plant samples were analyzed everyday to know whether the parameters were within the standards or exceeding them. The project was mainly divided into three parts. Like first part was to do analysis of the samples. Secondly, the parameters which are often crossing the APPCB standard values were to be identified and the third part was to take measures to bring those values within the APPCB standards.

TDS values were remarkably high in initial stage. Hence for TDS reduction different sizes of activated carbon in the filters was used. The main aim was to reduce TDS.

Most common treatment methods for TDS removal

1. Reverse osmosis.
2. Activated carbon filters.
3. Distillation.
4. Dilution.

Reverse Osmosis (Ultra Filtration): Reverse Osmosis is a water purification technology that utilizes normal household water pressure to force water through a selective semi permeable membrane that separates contaminants from the water. Treated water emerges from the other side of the membrane, and the accumulated impurities left behind are washed away. Eventually, sediment builds up along the membrane and it needs to be replaced. Reverse osmosis is highly effective in removing several impurities from water like TDS, turbidity, asbestos, lead and other heavy metals, radium and many dissolved organics. Reverse osmosis and activated carbon filtration are complementary processes. Combining them results in the most effective treatment against the broadest range of water impurities and contaminants. Reverse osmosis systems have two major drawbacks. First, they waste a large amount of water. They will use 3 to 9 gallons of water per gallon of purified water produced. This could be a problem in areas where conservation is a concern, and it may be slightly expensive if we are paying for municipal water. On the other hand, this wastewater can be recovered or redirected for purposes other than drinking, such as watering the garden, washing the car; etc. Second, reverse osmosis treats water slowly; it takes about three to four hours for a residential reverse osmosis unit to produce one gallon of purified water. Treated water can be removed and stored for later use.

Activated Carbon Filtration: Carbon adsorption is the most widely sold method for home water treatment because of its ability to improve water by removing disagreeable tastes and odours, including objectionable chlorine. Activated carbon filters are a very important piece of the purification process, although they are only one piece. Activated carbon effectively removes many chemicals and gases, and in some cases it can be effective against microorganisms. Only a few carbon filter systems have been certified for the removal of lead, asbestos, VOC, cysts, and coliform. There are two types of carbon filter systems, each with advantages and disadvantages: Granular activated carbon and Solid block carbon. Activated carbon is created from a variety of carbon based materials in a high temperature process that creates a matrix of millions of microscopic pores and crevices. One pound of activated carbon provides anywhere from 60 to 150 acres of surface area. The pores trap microscopic particles and large organic molecules, while the activated surface areas cling to, or adsorb, small organic molecules.

Granular Activated Carbon: Any granular activated carbon filter has three inherent problems. First, it can provide a base for the growth of bacteria. When the carbon is fresh, practically all organic impurities (not organic chemicals) and even some bacteria are removed. Accumulated impurities, though, can become food for bacteria, enabling them to multiply within the filter. A high concentration of bacteria is considered by some people to be a health hazard. Second, chemical recontamination of granular activated carbon filters can occur in a similar way. If the filter is used beyond the point at which it becomes saturated with the organic impurities it has adsorbed, the trapped organics can release from the surface and recontaminate the water, with even higher concentration of impurities than in the untreated water. This saturation point is impossible to predict. Third, granular carbon filters are susceptible to channeling. Because the carbon grains are held loosely in a bed, open paths can result from the buildup of impurities in the filter and rapid water movement under pressure through the unit. In this situation contact time between the carbon and the water is reduced, and filtration is less effective. To maximize the effectiveness of a granular activated carbon filter and avoid the possibility of biological or chemical recontamination, it must be kept scrupulously clean. That generally means routine replacement of the filter element at six to twelve month intervals, depending on the usage. Because of its molecular makeup, activated carbon can adsorb well, meaning that it can take in or collect many organic molecules on its surface. Granular activated carbon filters are typically inexpensive, and maintenance involves replacing six to twelve cartridges a year, depending on the quality of the raw water and the filter media. Specially designed solid block and precoat activated carbon filters are also available, which are effective at reducing heavy metals such as lead and mercury. Solid block filters with a pore size smaller than 0.2 microns are often effective against biological contaminants as well.

Other Treatment Processes: Distillation is a process that creates water by evaporation and condensation. Distillation is effective against microorganisms, sediment, particulate matter, and heavy metals. It will not treat organic chemicals. Good distillers will have a carbon filter to remove organic chemicals. Ultraviolet (UV) systems use UV light to kill microorganisms. These systems can be highly effective against bacteria and other organisms; however they may not be effective against giardia and other cysts, so any UV system you buy should also include a 0.5 micron filter. Other than some moderately expensive solar powered distillers on the market, any distiller or UV unit will require a power source. Dilution is the other method by which TDS can be reduced. The final treated effluent should be diluted with water and then can be used for different domestic purposes.

Role of Activated Carbon in TDS Removal: Adsorption in general is the process of collecting soluble substances that are in solution on a suitable interface. The interface can be between the liquid and a gas, a solid or another liquid. Although adsorption is used at the air-liquid interface in the flotation process, only the case of adsorption at the liquid-solid interface will be considered for the TDS removal.

In the past the adsorption process has not been used extensively in wastewater treatment, but demands for a better quality of treated wastewater effluent have led to an intensive examination and use of the process of adsorption on activated carbon. Activated carbon treatment of wastewater is usually thought of as a polishing process for water that has already received normal biological treatment. The carbon in this case is used to remove a portion of the remaining dissolved organic matter. Depending on the means of contacting the carbon with the water, the particulate matter that is present may also be removed.

Activated Carbon and its Use: The nature of activated carbon, the use of granular carbon and powdered carbon for wastewater treatment can be explained as following:

Activated Carbon Production: Activated carbon is prepared by first making a char from materials such as almond, coconut and walnut hulls, other woods and coal. The char is produced by heating the material to a red heat in a retort to drive off the hydrocarbons but with an insufficient supply of air to sustain combustion. The char particle is then activated by exposure to an oxidizing gas at a high temperature. This gas develops a porous structure in the char and thus creates a large internal surface area. The surface properties that result are a function of both the initial material used and the exact preparation procedure, so that many variations are possible. The type of base material from which the activated carbon is derived may also affect the pore size distribution and the regeneration characteristics. After activation, the carbon can be separated into or prepared in different sizes with different adsorption capacities.

Analysis of the Adsorption Process: The adsorption process takes place in three steps: Macrotransport, Microtransport and Sorption. Macrotransport involves the movement of the organic material through the water to the liquid-solid interface by advection and diffusion. Microtransport involves the diffusion of the organic material through the macropore system of the Granular Activated Carbon (GAC) to the adsorption sites in the micropores and submicropores of GAC granule. Adsorptions occurs on the surface of the granule and in the macropores and mesopores, but the surface area of these parts of the GAC granule are so small compared with the surface area of the micropores and submicropores that the amount of material adsorbed there is usually considered negligible. Sorption is the term used to describe the attachment of the organic material to the GAC. The term sorption is used because it is difficult to differentiate between chemical and physical adsorption. When the rate of sorption equals the rate of desorption, equilibrium has been achieved and the capacity of the carbon has been reached. Hence, by the pilot plant studies it is quite evident that the activated carbon used in the filters is useful in the removal of TDS. But, here one thing has to be taken care off, that the size of activated carbon plays a major role in the reduction of TDS. With the decrease in the activated carbon size the efficiency of carbon increases this is due greater surface area and hence TDS is reduced to a good extent. But, very fine powder of activated carbon is not as efficient as the porosity is very much increased and carbon cannot be properly packed and hence dissolved solids pass through the fine powder of activated carbon.

Pilot Plant Results and Discussion

1. The pH of the inlet sample ranges from 6.05-7.86 and the pH of the final tank ranges from 6.54-7.15. as shown in Table 1.

2. The COD of the inlet sample ranges from 160-400 mg/lt and COD of the final tank ranges from 120-240 mg/lt. The efficiency of pilot plant to remove COD is 33.4 % as shown in Table 2.

3. The BOD of the inlet sample ranges from 150-200 mg/lt and the BOD of the final tank ranges from 50-90 mg/lt. The efficiency of pilot plant to remove BOD is 60.8% as shown in Table 3.

4. The TDS removal is done by taking different sizes of Activated Carbon.

i) Size >40mm: The TDS of the inlet sample ranges from 2100-2540 mg/lt and the TDS of the outlet sample ranges from 1805-1905 mg/lt. The efficiency of the pilot plant with activated carbon filter of the size greater than 40mm to remove TDS is 22.89% as shown in Table 4.

ii) Size < 40mm: The TDS of the inlet sample ranges from 2405-3005 mg/lt and the TDS of the outlet sample ranges from 1205-1900 mg/lt. The efficiency of the pilot plant with activated carbon filter of the size less than 40mm to remove TDS is 42.77% as shown in Table 5.

iii) Size < 15mm: The TDS of the inlet sample ranges from 2540-3000 mg/lt and the TDS of the outlet sample ranges from 1105-1705 mg/lt. The efficiency of the pilot plant with activated carbon filter of the size less than 15mm to remove TDS is 52.01% as shown in Table 6.

Table 1: pH

Days	Inlet	Outlet
1	6.05	6
2	7.54	7.1
3	7.45	7.2
4	6.3	6
5	7.2	6.2
6	7.8	6.23
7	7.86	7.15
8	6.9	6.3
9	6.04	6
10	6.34	6
11	6.3	6.1
12	7.2	6
13	7.8	7.1
14	7.86	6.54
15	7.05	7

Table 2: COD

Days	Inlet	Outlet
1	348	240
2	256	220
3	160	120
4	345	148
5	260	220
6	380	234
7	390	220
8	245	228
9	342	300
10	320	240
11	400	227
12	345	240
13	234	125
14	400	190
15	340	220

Table 3: BOD

Days	Inlet	Outlet
5	150	90
10	160	60
15	200	50

Table 4: Activated carbon size Size >40mm TDS

Days	Inlet	Outlet
1	2100	1879
2	2200	1805
3	2478	1756
4	2436	1790
5	2200	1850

Table 4 (Cont.)

Days	Inlet	Outlet
6	2399	1780
7	2540	1754
8	2467	1852
9	2356	1896
10	2480	1905
11	2500	1899
12	2388	1900
13	2108	1840
14	2377	1740
15	2500	1750

Table 5: Activated Carbon Size Size <40mm TDS

Days	Inlet	Outlet
1	2497	1863
2	2405	1205
3	2508	1890
4	2670	1753
5	2569	1300
6	2545	1670
7	2675	1476
8	3002	1600
9	2567	1308
10	3005	1408
11	2876	1606
12	2864	1330
13	2854	1400
14	2987	1860
15	2902	1750

Table 6: Activated Carbon Size Size <15mm TDS

Days	Inlet	Outlet
1	2609	1174
2	2622	1167
3	2540	1105
4	2760	1560
5	2876	1290
6	2875	1108
7	2986	1156
8	2660	1705
9	2908	1200
10	2653	1675
11	3000	1129
12	2876	1197
13	2800	1453
14	2654	1123
15	2098	1590

CONCLUSION

Activated carbon plays a major role for TDS removal. Three different sizes of Activated carbon were used in the experiment. It was found that reduction in the size of activated carbon increases the efficiency to reduce TDS and that is due to the increased surface area. But very fine activated carbon is of no use as no proper packing can be done and it will have more particle space and hence dissolved solids easily pass through the spaces. Hence the size plays a major role for TDS removal and also proper back washing of filters is required.

ACKNOWLEDGMENT

It is my pleasure to express my gratitude and sincere thanks to my guide Dr. Paul S Magadati for his able guidance, encouragement and co operation, throughout the progress of the work.

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International Journal Life Sciences Biotechnology and Pharma Research
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ISSN 2250-3137
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