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Chapter

Physical Wastewater Treatment

Bahareh Pirzadeh

Abstract

Water is a valuable material. Water used to dispose of nature or enter the consumption cycle requires disinfection and purification to conserve water resources as well as to provide drinking water. Different processes are carried out on the water to increase water quality as much as possible. In general, the filtration process can be divided into two general categories. In the first process, harmful substances are removed from the water. In the second group, the processes are specifically designed to improve the quality and control parameters such as the pH value. The stages of water purification can be divided into different steps more in detail, which physical purification is one of these steps and has been discussed in this chapter.

Keywords: wastewater treatment, physical treatment, water quality, sewage dumping, active pharmaceutical ingredients, corrugated plate interceptor

1. Introduction

All societies, both solid and liquid, produce waste. Wastewater can be considered as a combination of waste produced by water from residential, administrative, commercial, and industrial facilities and drained into groundwater or surface water. Untreated wastewater contains pathogenic microorganisms and organic matter. Degradation of untreated wastewater organic matter produces stinking gases. Therefore, wastewater treatment is one of the essential measures that must be taken before discharge into the environment. Wastewater treatment is a practical solution to speed up the process of providing safe and transparent reusable water.

The pollutants can be removed from wastewater using a variety of ways that are divided into three main categories: physical, chemical, and biological processes. A purification process generally consists of five successive steps as described in Figures 1 and 2: (1) preliminary treatment or pre-treatment (physical and mechanical); (2) primary treatment (physicochemical and chemical); (3) secondary treatment or purification (chemical and biological); (4) tertiary treatment (physical and chemical); and (5) treatment of the sludge formed (supervised tipping, recycling or incineration) [1, 3].

Physical wastewater treatment is the first step in the treatment of industrial and sanitary effluents, which in addition to increasing the efficiency of other steps, prevents damage to the equipment used in chemical and biological treatment. The equipment and processes used in physical wastewater treatment vary according to the type of effluents and the quality desired for wastewater. In other words, since the wastewaters are mostly very colored and contain high biological and chemical oxygen, they have high electrical conductivity and are considered chemically alkaline.
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In other words, since the wastewaters are mostly very colored and contain high biological and chemical oxygen, they have high electrical conductivity and are considered chemically alkaline. Accordingly, different parameters affect the cost of selecting a wastewater treatment method. Factors such as the type of pollutants to be treated, the chemical composition of wastewater, the cost of chemicals required, the operating cost, the cost of collecting waste generated by the treatment process, affect selecting a wastewater treatment method [4].

Based on the various processes and steps mentioned for the physical treatment of industrial and sanitary effluents mentioned above, equipment such as the following is required:

![Figure 1. Main processes for the decontamination of industrial wastewaters [1].](image1)

![Figure 2. Primary and secondary treatment of sewage [2].](image2)

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Based on the various processes and steps mentioned for the physical treatment of industrial and sanitary effluents mentioned above, equipment such as the following is required:
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- Types of garbage (manual, mechanical and even grating)
- Settling pools and sludge bridges for collecting deposited sludge
- Classifier and a variety of granular to remove fine grains such as sand

In this chapter, we will explain each of the above.

2. What is physical wastewater treatment

The separation process of particulate matter and solids in industrial and sanitary effluents is called physical purification. Depending on the type of sewage, there may be pieces of fabric, the foliage of trees, sand and plastic parts, etc. in the fluid entering the treatment plants. Entering these particles into wastewater treatment equipment such as pumps, pipes, and fittings may cause damage. In addition, the failure to remove these items causes a lot of pressure on the equipment in chemical and biological wastewater treatment, and their output quality decreases. For this purpose, with practical and simple equipment, physical treatment processes of industrial and sanitary wastewaters are implemented.

3. The most important steps of physical wastewater treatment

3.1 Sewage dumping

Considering the capacity of the treatment plant and the speed of entering fluid, and the size and amount of dissolved and suspended solids in the wastewater, it is necessary to install appropriate littering in the inlet of the sewage canal. The litters used in this step of physical wastewater treatment are varied, and each one has specific features, the most important of which are the following options:

3.1.1 Mechanical garbage collector

Other types of littering used for large refineries include mechanical garbage collectors. The most important feature of this equipment is that the engine is on top of it. So, after accumulating solid particles in the sewage on the blocker screen, the collection process is done. The mechanical garbage collector is divided into the bar, lattice or lace, strapping, round-trip rod, chain, and cylindrical movement groups in terms of appearance structure. In this type of garbage collector, human resources are not used. It can remove suspended solids up to 2–3 mg. It should be noted that the necessary force for motor movement in mechanical garbage is supplied from electricity and therefore has higher energy consumption than the manual type (Figure 3) [5].

3.1.2 Handheld sewage collector

A handheld screen consisting of several bars is located at certain distances and prevents particles with a size greater than two centimeters from entering the treatment plant. As the name of this equipment is known, after accumulating particles and solid patches on the plate, human operators perform the collection process. Garbage
Figure 3.
Bar rack and traveling screen [5].

Figure 4.
Preliminary Treatment of Sewage [6].
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collectors have different types of fine and coarse grain. Due to the lack of electricity, it is cost-effective for the physical treatment of wastewater. It should also be noted that the material used to make the body and screen is resistant to acidic and corrosive materials and has a long lifespan (Figures 4 and 5) [5].

3.1.3 Mechanical sewage collector

The grating pair is composed of two lattice plates and nets that block the passage of sewage. This type of littering is located in the group of mechanical garbage collectors and without the use of a human operator, the collection of accumulated materials on the plate is done. Due to the use of two lace plates in the overall structure of this

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mechanically cleaned</th>
<th>Manually cleaned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width (mm)</td>
<td>5–20</td>
<td>5–20</td>
</tr>
<tr>
<td>Thickness (mm)</td>
<td>20–80</td>
<td>20–80</td>
</tr>
<tr>
<td>Bars cleaner spacing (mm)</td>
<td>20–50</td>
<td>15–80</td>
</tr>
<tr>
<td>Slope from vertical (degrees)</td>
<td>30–45</td>
<td>0–30</td>
</tr>
<tr>
<td>Approach velocity (m s⁻¹)</td>
<td>0.3–0.6</td>
<td>0.6–1.0</td>
</tr>
</tbody>
</table>

Table 1. Design parameters and criteria for Bar screens [5].
screen, its efficiency and efficiency for physical treatment of wastewater and removal of suspended solids are high and with the destruction of one plate, it is possible to continue working with another plate [5].

The garbage collectors are designed based on the diameter of the seeds to be removed, the width and depth of the canal and rods, the distance between the rods, the vertical slope, the speed and the loss of the allowed head.

Table 1 shows some design parameters and criteria for mechanically and hand-cleaned screens.

4. Deposition of particulate matter in wastewater

Industrial and sanitary wastewaters are not completely cleaned of suspended materials despite passing through multiple filters (littering). Many of these small particles will settle on the floor of the treatment plant, depending on their weight if they have the opportunity. The second important process in the physical treatment of industrial and sanitary wastewaters is to allocate time for settling suspended materials in special pools. By doing so, largely fine and particulate matter is transferred to the bottom of the pool and gradually converted into sludge, which will be periodically drained (Figure 6) [7].

5. Removal of sand and fine particles in wastewater

In the last steps of the physical treatment of wastewater, it is necessary to provide a solution for the removal of very fine sand. One of the best solutions in these conditions is floating using equipment such as a classifier. Grit Classifier is placed in a simple but functional wastewater treatment equipment group that has different parts such as body, cochlear conveyor, and Electra Gearbox. Water enters the grit classifier body from the inlet valve. The cochlear conveyor flows the strip and creates centrifugal force. Fine particles and sand grains are separated from the water due to the creation of this force. They move to the device output and exit from it. Finally, wastewater without sand particles and similar items will be obtained.

Figure 6. Sewage settling pond.
6. Active pharmaceutical ingredient (API)

Active pharmaceutical ingredient (API) is one of the most widely used and oldest systems for removing fat and oil from water, wastewater, and wastewater. These systems tend to remove free oil down to less than 15 mg L$^{-1}$ [7]. The construction of water and oil separators by API method is similar to a rectangular clearinghouse, although they have different sizes and design details.

These grease traps are used to remove free oil as well as solid particles from wastewaters of refineries, petrochemicals and chemical plants and other industries. These grease traps are designed according to the standards published by the American Petroleum Institute. The basis of this type of separator is the difference in specific gravity. Less specifically-weighted liquid (usual oil) is collected from the surface, while the fluid with more specific gravity remains in the lower part. Wastewater may contain insoluble oil, sludge, and some soluble components. In common API degreasers, wastewater is initially collected in a pretreatment section for sludge collection. Baffles allow the sewage flow to move slowly towards the outlet, and the oil is separated from the water and effluent.

Usually, in the process of API grease traps, the oil layer, which may contain amounts of water and suspended solids, must be continuously emptied. This layer of isolated oil may be reprocessed or destroyed to recover valuable products. The sedimentary layer containing solid particles formed at the bottom of the degreaser is removed by a remover (or similar device) and a sludge pump.

In the design of API grease traps and other similar gravity tanks, if the input current meets the following conditions, the performance of the grease traps will be difficult:

- The average size of oil droplets in the feed is less than 150 microns,
- Oil density is greater than 925 (Kg m$^{-3}$),
- Water temperature is less than 5°C,
- The amount of hydrocarbon in the inlet flow is high.

7. Corrugated plate interceptor (CPI)

In addition to the grit classifier at this stage, different types of grease traps can also be used. For example, CPI degreaser is one of the most applicable equipment in this field. It is a kind of gravity separator and causes colloidal particles suspended in wastewater with a size of at least 50 microns to be separated from wastewater. This type of degreaser, sometimes called Tilted Plate Interceptor, has widely replaced API separators and primary settling tanks [8].

In CPI fat, the inlet wastewater is transferred to the machine to diagonal plates at an angle of 45 to 60 degrees. These plates have resin-reinforced layers, eventually causing the fat particles to settle above the surface of the sewage and the rest that weighs heavier. The simple structure of this method reduces the cost of construction and maintenance of facilities. One of the most important uses of CPI separators is oil and gas refineries, oil terminals and ports, repair shops, food industry, detergent, and chemical production industries, automobile manufacturing, and petrochemical industries. The advantages of this method are:
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- High efficiency of oil and fat removal
- Low energy consumption
- Simple operation
- Using corrosion-resistant plates, acid, alkalinity
- The dense structure raises concerns about deformation.

8. Dissolved air flotation (DAF)

The removal of pollutants and colloidal particles by injecting compressed air into the effluent is called “Liquid Air Flotation” or “Degradation” of DAF wastewater. As a result of this action, finely released bubbles cling to colloidal particles suspended in the sewer, causing the particles to float on the surface where they are collected by the skimmer and discharged into a sludge storage tank (Figure 7). Due to the high efficiency of the DAF degradation system, this equipment is widely used in various industries such as oil and gas refineries, food factories, and chemicals [7]. DAF is an alternative to sedimentation [9].

In the design process of the DAF wastewater degradation machine, several steps are considered for the removal of oil and colloidal particles suspended in water, including [10]:

- Compressed air enters the reservoir and storage of sewage and water, causing bubbles in the fluid.
- Bubbles created in the liquid cling to colloidal particles and transfer to the highest level of the liquid.
- After oily and colloidal particles are placed on the surface of the water, they are collected using skimmers.

To increase the efficiency of the DAF wastewater degradation system, it is better to use coagulants according to the fluid type and particulate matter in it. To do this,
add to the inlet effluent of coagulants and polymers to make the load of the particles. For this purpose, spiral tubes are used, which on the one hand, coagulants are injected in different parts, and on the other hand, an air mixture with pressurized liquid is injected into these tubes for better mixing.

In the DAF grease trap system, some of the cleaned and cleared water is inserted into the flocculants pipes and part of it is transferred directly to the floating unit.
Excess treated water is also removed from the DAF system. Clearness of the outlet water from the DAF unit is one of the criteria for the proper operation of this system. In some cases, coagulation and flocculation tanks are used instead of flocculants tubes. In this case, the coagulants are mixed with effluent in the coagulation tank for about 5 minutes and then injected into the DAF. This process is superior to tubular flocculants when the input effluent is not neutralized and there is enough time to neutralize and on the other hand it is easily controlled by the user.

The objective of the Coagulation Process is to create micro-floc from particulate matter, agglomerate the particles, so that they can settle and move to the sedimentation process. At the Flocculation Process stage, another chemical can be added, a polymer, which helps keep the macro flocs together. Essentially it helps make the bridge between the micro flocs stronger when forming the macro-flocs. A Floculator is three or more basins with separate mixers. At each stage there are various sizes of flocs, as the size of the flocs increase, the power on the mixers is decreased, to prevent shear, and not damage the flocs (Figures 8 and 9).

9. Conclusion

Wastewater treatment is a process in which wastewater (water that is no longer needed or suitable for use) is converted into water that can be restored to the environment and drained in the wild. Wastewater treatment procedures are carried out in 3 ways: chemical treatment, physical treatment and biological treatment.

Physical treatment of wastewater is when physical and mechanical properties and separation and removal of external particulate matter from wastewater are used. Littering, grading, floating, sequestration and other processes are examples of these.

Physical wastewater treatment is the first step in industrial and sanitary wastewater treatment and not only improves the effectiveness of subsequent processes, but also protects chemical and biological treatment equipment. The equipment and techniques used in physical wastewater treatment vary depending on the type of wastewater and the quality of the wastewater.

Physical methods of water and wastewater treatment include different stages of settling, filtration, and aeration that were discussed in this chapter.

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