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Treatment of Urban Wastewater

Hanane El Fadel*
Laboratory of Biotechnology, Environment, Food and Health. Sidi Mohammed Ben Abdellah University, Morocco

Abstract

The evolution of raw wastewater to a purified effluent occurs through various stages or streams that constitute successive purifications.

These successive stages of physical, chemical or biological characteristics are combined in order to first eliminate or reduce suspended matter, then colloidal materials and finally dissolved elements, whether mineral or organic.

These treatments are distinguished according to the degree of purification sought and the technical means employed; the classification includes:

a. Preliminary treatments
b. Primary treatments
c. Secondary treatments
d. Complementary treatments, sometimes referred to as tertiary or advanced treatments

The purpose of these purification processes is to obtain a satisfactory effluent for which pollution is limited to such a degree that the discharge does not create any nuisance to the flora or fauna of the receiving environment.

Keywords: Preliminary treatment, Decantation, Coagulation-flocculation, Polyelectrolytes, Filtration, laguning, Bacterial bed, Activated sludge, Chlorination, Ozonation

Introduction

Given the nature of urban wastewater (domestic and runoff) and its composition, it is reasonable to consider that treatment techniques for these waters are currently at a point.[1] However, certain biological processes and phenomena must be explained in order to deal more effectively with the various processes and channels of purification of these effluents; indeed, there is now agreement that the application of biological phenomena, the physical or chemical processes play an important role in the means of urban waste water treatment and that, through technological transfers, there is a certain analogy between the treatment systems "drinking water" and "waste water".

All living things, including bacteria, are sensitive to the environment in which they live;[2] often the pollutant stream of wastewater is poorly analysed and varies over time in flow and concentration, all this constitutes constraints that complicate and disturb the environment singularly. It must also be acknowledged that the performance of the purification processes is not unlimited and that there will remain, in any case, residual pollution which will affect the quality of receiving water downstream of the treatment plant.

This work covers the field of urban wastewater treatment, as well as effluent treatment lines and design aspects, To enable designers and decision-makers to find the best solution for constructing and operating works under the most satisfactory technical and economic conditions. By the scope of the area covered, this work brings together the maximum amount of information and knowledge essential to carry out the projects of public authorities and especially to safeguard the receiving environments too often

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***Corresponding author:** Hanane El Fadel, Laboratory of Biotechnology, Environment, Food and Health. Faculty of Science Dhar El Mahraz, Sidi Mohammed Ben Abdellah University, Fez, Morocco

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victims of urbanization, the neglect of individuals. It is a true essay of synthesis of the discipline, easy to read, while remaining in a rigorous practical framework.

It is therefore aimed at both project managers and supervisors, as well as engineers in cities and public administrations, private practitioners and companies that build and operate the networks and sewage treatment plants. Students will also find a significant source of information.

Urban Wastewater Treatment Processes

Basic principle

The aim of the purification processes is to obtain a satisfactory effluent, for which pollution is limited to such a degree that the discharge does not create any nuisance to the flora or fauna of the receiving environment.[3] Each country sets, in its own health legislation, the limit of tolerable pollution for discharges into rivers. To carry out the purification of waste water, one is led on the one hand to retain the waste which will be discharged to nature in the form of inert products usable for agriculture and gaseous products having a certain energy value and, on the other hand, to obtain finally a effluent purified at various levels of efficiency and discharged to nature.[4]

Instability of wastewater

The composition of waste water is highly unstable, and it can be modified to a greater or lesser extent by certain changes in circulation conditions:[5]

a. The turbulence of water currents in the network which improve oxygenation of the medium

b. The slowdowns of the effluent flow in the pipes, which cause sedimentation phenomena and the proliferation of anaerobic bacteria

c. Percolations through a porous bed that produce clogging on which a biofilm appears at the top of the bed, resulting in intense microbial activity

d. The fineness of some suspended matter prevents water from settling

e. The gas-liquid contacts, which are operated by bubbling air bubbles of different sizes inside the porous bed, the rise of the bubbles causing mixing of the suspended fine materials

f. Finally, sometimes the large dimensions of suspended materials that can cause pipe fillings (sands, gravel, paper, rags...)

In summary, it must be admitted that all these factors, which are of a different nature, have as their consequence, during the studies, the design of a network and a sewage treatment plant to operate under difficult conditions, This is all the more so since the flows do not occur without high permanent pressure.

It must finally be understood that these successive purifications involve physical, chemical and biological phenomena within the entirely artificial installations which constitute the treatment plants.

Preliminary (or Mechanical) Treatments

According to the experts, preliminary treatments are the necessary prerequisites for any purification process.[6] At the head of a treatment plant, raw water is loaded with bulky materials; these must be retained by simple processes in order to protect downstream treatment plants. This protection is usually carried out by implementing the works detailed below.

Inlet spillway and gauge station

The inlet spillway and the gauge station, for single-unit systems, limit the volume of water admitted to the treatment plant by 4 to 5 times the dry-time flow rate. Indeed, The station cannot function properly if the flows it receives are too variable.

Sand-clearing chamber

The sand removal chamber protects the treatment plant against the intrusion of sands and heavy materials (gravel) with a particle size greater than 200 microns. The granulometry below 200 microns is the spring of decantation. The study of sand-blasting is linked to that of free fall sedimentation phenomena. For the calculation of sedimentation velocities, a density of 2,65 is assumed for sand particles. To achieve the training of organic matter covering gravel, it is necessary to obtain a speed of 0,30 m/s.

Sand trapping is carried out:

i. Either by longitudinal decanters where the speed of water is reduced to 0,30 m/s; removal of materials is carried out every 5-6 days by hand or by compressed air suction pumps

ii. Either by circular decanters known as "tangential" where the effluent is set in motion by air injection comparable to a centrifugation

iii. Either by aerated rectangular sand drills, in which the air blown in causes a rotation of the liquid with sweeping of the bottom

The very often important de-sanding of certain waste waters is carried out in circular-shaped "scraped-off de-sand tanks" of 6 to 18 m diameter or by pressure cyclonage.

Entrance gates

Bulky materials are held through the grates. This is always done before a lift station. The grids generally vertical or inclined at 60°

are made of bars whose spacing can vary from 20 to 60 mm. We can distinguish:

a. Pre-screening (spacing of bars): 30 mm to 60 mm

b. The average fence (spacing of bars): 10 mm to 30 mm

c. The fine grid (spacing of bars): 5 mm to 10 mm

The removal of materials, or screening, is done manually or mechanically, the latter mode being strongly recommended. Flow velocity ranges from 0,60 to 1 m/s and the average waste water volume in urban wastewater is 20 l/inhabitant/year. The shredding of waste is not recommended because it increases the solid residue content in treatment plants. If a more extensive screening is carried out using sieves with finer or thinner mesh, the operation is called "screening" and reduces the pollutant load arriving at the treatment plant.

Degreasing chamber

The degreasing chamber allows to separate from the raw effluent oils and fats coming not only from homes but also from garages, restaurants, factories, slaughterhouses, in order to reduce clogging and avoid some inhibition of biological processes. This separation is carried out by difference in density, the oils and fats surging in a chamber where the waters are «tranquilized» in a siphoid partition tank. It can be noted that an injection of air at the bottom of the separation chamber allows the fat to be more easily captured by causing them to rise up to the surface. This pre-aeration of effluents facilitates the purification of downstream waters. The removal of oils and fats is carried out by manual or mechanized skimming. Currently, before the discharge of wastewater from restaurants, kitchens, large commercial areas, into public sewers, the health administration requires users to install grease separators.

Primary Treatment

The primary treatment processes are physical, such as more or less thorough settling, and possibly physico-chemical; the waste thus collected constitutes what is called primary sludge.[7] They eliminate 50% to 60% of the suspended substances which can be settled in water and reduce the BOD by between 25% and 40%, depending on the characteristics of the structures or equipment; this significant reduction in pollution is usually achieved at very little cost.

Physical decantation process, sedimentation

The basis of this solid-liquid separation process is gravity. Decantation is expressed when one wishes to obtain the clarification of a raw water, but if one tends to want to obtain a concentrated sludge, we express ourselves by the term sedimentation. The grained mineral matter and the suspended floated organic matter are deposited at the bottom of the basin or remain suspended in the water, the following relation can be applied to the decanting mechanism :

$$F = \gamma \frac{(S1 - S2)}{V}$$

With

F : Vertical force from top to bottom

γ : Gravitational constant

S_1 : Density of the particle

S_2 : Density of the fluid

V : Volume of the particle

The rate of settling also varies according to the temperature of the water, it is assumed that a rise in temperature from 0°C to 30°C doubles the rate of decanting, this because the density and viscosity of the water have decreased.

The suspended bodies or colloidal materials in the wastewater tend to separate from the liquid by sedimentation, these so-called coalescent particles decant by the fact that they agglomerate and weigh. The sedimentation process for a given effluent is observed after a stay of 2 hours in settling flasks of 0,40 conical height and 1 litre of capacity. The force of gravity is used to separate particles of different densities.

The sedimentation rate slows down when the dimensions of the suspended particles decrease, with the particle falling rate being proportional to the square of their diameter (Stokes' law). Thus, for suspended particles of various diameters, the experimental indications in Table 1, giving the falling velocities at a temperature of 10°C, can be adopted according to FAIR.

Table 1: Rate of fall of certain particles according to their densities

Nature of the particles	Particle density	Particle diameter (mm) and drop rate (m/h)						
		1	0,5	0,2	0,1	0,05	0,01	0,005
Sand	2, 65	502	258	82	24	6,1	0,3	0,06
Coal	1,50	152	76	26	7,6	1,5	0,08	0,015
Suspended matter in domestic wastewater	1,20	122	61	18	3	0,76	0,03	0,008

This table shows:

a. The rapid and large-scale settling of sand (density materials: 2, 65)

b. A very low sedimentation rate of suspended matter; this finding justifies the need to agglomerate these fine particles together to form elements of large sizes, in order to eliminate them more easily

c. It should be noted that the flow rate remains unaffected by decantation in a horizontal run-off basin as long as a certain speed limit is not exceeded. This limit speed is on average 50 mm/s, or 180 m/h. Beyond this flow rate of effluents, the sludge particles may be carried by the current and do not settle on the bottom of the basin

d. The design of decanters is essentially based on

e. The rate of sedimentation of suspended solids which can only be measured by tests on samples taken from the effluent to be treated

f. On the hydraulic load in m^3

g. On the organic load expressed in kg of Suspended Solids

In primary settling systems, a passage time of between 2 and 3 hours is generally accepted for effluent if a separation network is considered; on the length of this route only microorganisms linked to sedimentable matter can settle.[8]

Lamellar decanters

The decanting can be carried out in longitudinal basins, whose walls are inclined at a slope of 45 to 60 degrees. These basins are similar to the sand-blasting chambers, except that the speed of the effluent is much lower; these are generally defined by an average crossing time between 1h and 1/2 and 2h for the dry weather effluent, with a more or less pronounced overload in case of rain, when it is a sanitary effluent. A longer duration of 3 hours would lead to fermentation risks, which would affect the yield of the settling by the fact that the gaseous bubbles would tend to make the sludge deposited rise.

Apart from rectangular or circular decanters, it is worth mentioning the use of decanters with plates or tubes, inclined to 60 degrees. This device, known as a « lamellar decanter », has an efficiency of sedimentation which depends on its horizontal surface; these decanters can be arranged in parallel; the flow of the effluent is made from bottom to top or cross-current.

According to these provisions, the partial length of the traditional decanter is divided into "n" superimposed elementary decanters spaced 5 cm to 10 cm apart, which allows for an increase in the flow rate of raw water inlet; This is an accelerated settling process which has been further improved by combining the effect of lamellar settling and contact with a mud bed. This type of decanter allows to trap very quickly the fine colloidal particles since the drop height of the particles is only 4 to 9 cm, it adapts well to the variations of pollution loads carried by domestic wastewater.

By stacking «n» elementary decanters the surface of decantation is multiplied by the number of plates, so that the space of this type of decanting occupies a very small place. This advantage is supplemented by the fact that the waste water passage time is shorter, that is to say 6 to 20 times shorter than that of a traditional decanter; of course it is necessary to ensure a good distribution of effluents in each elemental decanter. It is also recommended to have a fine sieve lamellar decanter upstream. Lamellar decantation is considered to have an excellent purification performance which is explained by the formation of a real current of sludge on the upper face of the plates.

Static decanters

At present, it seems that the traditional static decanters will in many cases be abandoned in favour of lamellar decanters; moreover, with these devices the physical-chemical purification processes will be used very commonlychemical, polyelectrolytes and floats. In all cases, the settled water, after its passage in 1 or 2 hours, is transported to the purification plants by pumping or gravity. The removal of the settled products concentrated in mud pits can be carried out by pumping or suction with slurry pumps because of their high humidity (92%); sometimes this removal is carried out by gravity under hydrostatic pressure, by intermittent releases, once every 24 hours. It should be noted that the volume of sludge extracted from primary decanters usually reaches 2 l/ hab/d.

Physico-chemical decantation processes/ Coagulation-flocculation

The physico-chemical methods of settling consist in making the suspended particles heavier. They use coagulation or flocculation-clarification techniques[9] adopted for the treatment of drinking water. Coagulation and flocculation processes are used to separate suspended solids from water when the natural settling rate is too slow for effective clarification.[10] The coagulant reagents introduced into the wastewater have an «adsorbent» power; in other words, they have the effect of neutralizing the electric charges carried by the colloidal substances, charges which, by electrostatic repulsion, They maintain the particles in a dispersed state; furthermore, they promote their coagulation, thus increasing the size and density of large clusters, referred to as flocs; they increase thereby their aptitude for accelerated settling. The falling speed of particles being proportional to the square of their diameter, it is understood that it is interesting to bring together the smallest ones to form a large one. The process by which these substances coagulation is called coalescence and flocs in decant state constitute the mechanism of flocculation or coagulation at the level of very small particles. These reagents are of mineral origin (alumina sulphate, ferric chloride, lime)[9] or organic origin (as some flocculation adjuvants which are hydrophilic products that can form kinds of «gels» to increase the volume of the flocks).

The implementation of coagulation or flocculation is done after a study of raw water. Ferric chloride is used at 25 mg/l, but it has been observed that, at equal doses, alumina sulphate is a more efficient coagulant.

The mechanism of these reagents (mineral or organic) is sensitive to the pH of the effluents, it results in an adsorption and electrostatic action of colloidal materials and to obtain the best results the pH of the raw waters must be between 6 and 7.5.

Because of the cost of reagents, a mode of regulation must be sought which adjusts the injection of the reagent in relation to the pollution load to be treated. This optimal dosage of the hydrolysable mineral salts varies according to their chemical nature and the importance of the pollution to be eliminated, which presupposes:

a. A comprehensive study of the settling of raw water
b. Knowledge of MES and oxidable loads, that is to say the COD and BOD_5
c. The judicious application of the dosages of reagent to be injected, flows and concentrations of pollutant charges variable in time and daily rates; 5 different times are generally allowed

This control equipment is designed from pre-programmed clocks or by devices based on the turbidity of raw water or by the system «Autofloc» more advanced which fixes the optimal dosage of reagent to be injected into the effluent according to the degree of concentration of pollutants.

The physico-chemical processes have the advantage of a quick start (10 hours) and an immediate adaptation to variations in the flows of the effluents to be treated. They are also practically insensitive to seasonal climatic variations, to the qualitative changes of the wastewater and can in no way be disturbed by the presence of substances toxic to bacteria. In general, it must be recognized that the physico-chemical processes involve considerable operating costs and that the production of sludge is considerable, especially if lime is used. It should also be noted that lime, often used because of its low cost, causes high pH (crusting water) for purified water, which hinders downstream biological purification.

The physico-chemical processes are recommended in particular for the remediation of coastal areas, before discharge into the sea, and mountain resorts.[11]

Use of polyelectrolytes

The techniques of accelerating settling have recently evolved considerably with the addition of synthetic polymers, called polyelectrolytes. Polyelectrolytes are synthetic organic materials made up of large water-soluble molecules; they have a positive ionic charge (cations) or negative ionic charge (anions). These are low-dose, high-flocculation substances due to their electrical properties and do not affect the water's dissolving power, as occurs when using alumina sulphate for example.

These highly polymerized organic compounds are easy to use. This use of polyelectrolytes is interesting in the following cases:

a. Primary treatment plants subject to a specific pollutant load that is too high
b. Installations with too high a hydraulic load

Anionic products are recommended for both diluted and fresh waste water (higher pH values) and cationic products for concentrated and septic waste water (lower pH values).

Flotation processes

It is a solid-liquid extraction technique to separate particles suspended in water. In water with a high organic content, solids are brought to the surface by air blowing in the form of foam, which is then removed by scraping off the water surface. Very fine air bubbles (50 to 70 microns) cling to the fine particles to be removed. In order to have a better distribution of air bubbles, circular floats are used and it is common to find foam thicknesses of 15 to 30 cm. The physical laws governing the separation of phases in flotation are the same as those governing decantation.[12]

Secondary Treatments

Generally, the required rate of treatment for effluent discharge into the natural environment is not achieved by simple preliminary and primary treatment. The secondary treatments are intended to continue the purification of the effluent from the primary decanter. By biological means, most often, these settled waters are processed upstream, within acceptable limits, in order to ensure the imputrescibility of the effluent through the stabilization of organic matter. At this stage of final stabilization, all waste, sludge and gases are removed.

Physical and chemical purification processes

The implementation of physicochemical processes used in urban water treatment is relatively recent and has been satisfactorily adapted to domestic effluents with varying levels of pollution of all kinds, particularly inhibitory or toxic elements.

Indeed, there are excellent cleaning efficiencies, since the elimination of Suspended Solids is between 80% and 95%, that of organic materials between 65% and 75% and finally the phosphates to 90%. Furthermore, while the average response time of a biological purification remains between 12 and 24 hours, that of a physico-chemical purification does not exceed 1 hour. These positive results show that the operation of these stations is simple and very flexible, and that the use of lamellar decanters is well suited to this purification process, Especially if a polyelectrolyte is used in the final phase, which promotes flocs thickening.

In return, the operator faces three problems:

a. The increase in sludge production from 15% to 25%

b. This increase in the volume of settled sludge can affect the proper functioning of lamellar decanters

c. The one of insufficient removal of organic matter

Natural biological processes

Natural biological processes carry out the purification by soil, or through solar energy, organic pollutants (biomass of water) are degraded.[13] In practice, they have three aspects and can be used as complementary treatment of the effluents from an artificial biological treatment plant to perfect the elimination of undesirable substances such as nitrogen and phosphorus. They include soil application, lagoon or pond stabilization, and filtration through the soil.

Soil cleaning

Soil application is a true biological purification process. The organic matter contained in the water is retained by the soil particles, then destroyed by bacteria which proliferate by billions in the surface layers of the soils; when to the nitrogenous matter existing as organic nitrogen (or ammonia nitrogen), they are denitrified by the plants growing on the surface of the ground.[14]

Soil by its nature must be permeable to air on the surface where microbial activity is located.

It is essential to know:

a. Effluent flow rate

b. BOD_5 and COD

c. Suspended solids

d. Temperature and pH water

This process is generally adopted when the pollution density and industrial activity of the municipality are very low. Large areas of land must be properly drained. Temperature, sunshine and atmospheric precipitation are also factors in success. The size of the areas to be available is from 20 m^2 to 50 m^2 per equivalent-inhabitant. The opinion of a geologist is essential to determine precisely the filtering power of the soil and the absence of risks of contamination of groundwater.

The purification is carried out by irrigation or by spreading itself or by spraying. Irrigation is by the runoff of water from a surface area, while actual spreading is a combination of irrigation and artificial drainage. As for the sprinkler, these are lines pressurized by motor-pumps that feed mobile pipes that are moved as and when necessary. In practice, the effluent is often transported after settling. Intermediate storage in two or three basins is recommended by separating polluted water from unpolluted water.

For information purposes, some details are given below concerning the rates of application on the soil of waste water, which is an interesting method of purification if it is used rationally.

Volumes are in cubic metres likely to be discharged per hectare per year:

- Cereals ……………… 3 000 m^3/year
- Market crops.... 10 000 m^3/year
- Prairies………………… 100 000 m^3/year
- Land United................. 200 000 m^3/year

Sanitary regulations are against the cultivation of vegetables and fruits on these fields for raw consumption.

Natural laguning or stabilization basin

Stabilization basins or ponds may be used to treat, in the raw or decanted state, either domestic wastewater or organic matter from industrial wastewater, whether or not these are mixed with domestic wastewater.

Three types of lagoons are distinguished:

a. Deep lagoons (3 to 4 m) operating in anaerobic conditions

b. Shallow lagoons or large-area stabilization basins (1m), in which the mainly aerobic bacterial flora, hydrolyses organic matter and degrades it thanks to the oxygen supplied by the activity of surface algae (which find there a favourable environment for their development) and by air-water gas exchanges at the liquid surface

c. Finishing lagoons in addition to traditional and aerobic treatment

The most common type of lagoon used for complete wastewater treatment is the stabilization pond. It is one or more series basins, in which the raw effluents are subjected to natural biochemical processes of self-purification; generally these series basins are three. The internal environment of the basins is obviously more or less rich in oxygen and the biochemical phenomena operate as follows:

I. In the lower water area, anaerobic bacteria stabilize organic matter in two phases in the "boundary layer"; some of this material is broken down into nitrates and phosphates under the influence of enzymes from certain bacteria. then joins the upper phase of the water body; the other part of the matter is, by another group of bacteria, transformed into methane, carbon dioxide and ammonia;

II. In the upper zone, organic matter is degraded by oxygen and aerobic bacteria; this transformation produces carbon dioxide, water, phosphates and nitrates, and these mineral elements are used as food for aquatic flora. Note that aerobic bacteria, very hungry for oxygen, seek the extra oxygen necessary for their life and reproduction from surface algae, which, by photosynthesis, produce oxygen; This transformation is all the more intense as the climate is warm and sunny.

Purification by filtration through the soil

Without cultural enhancement

The possibility of disposing of large areas of sandy soils with a suitable fine grain size (0,2 mm to 0,5 mm) and on surfaces where there is no agricultural activity is used; water is directed over the entire extent of these surfaces, Based on effluent corresponding to a population of 2 000 per hectare of land.

Dune basins

Although the phenomena that occur during the purification of sewage infiltrated into the soil are still little known, It seems interesting to report the application of natural infiltration methods for biologically treated domestic wastewater in several basins, each measuring about 750 m^2, on bare dunes or by irrigation on planted dunes. The dune soils are formed of coarse sands with 80% elements between 0,2 and 1 mm and less than 5% fine elements (silts, clays); they constitute a permeable medium where the risk of clogging is controlled.

The excellent elimination results are:

a. BOD_5 = 90%; COD = 95% to 98% and SS = 100%

b. Total disappearance of pathogenic germs

c. Reduction: 43% of nitrogen and 100% of phosphates

d. Very low odour in relation to the environment

Artificial biological processes

Apart from the natural biological processes developed above, artificial biological processes are available to perfect this purification. These include devices that allow the localization of small areas and the intensification of processes for the transformation and destruction of organic matter as they occur in nature. Two main types of processes are used: one using bacterial beds, the other using activated sludge. Other systems related to these two processes are to be examined; they include plastic tubes, rotating biological discs, intense and prolonged aeration processes, total oxidation (oxidation blocks and oxidation channels), the aerated laguning and the use of pure oxygen.

Bacterial beds

The principle of a bacterial bed, sometimes called a bacterial filter or percolator filter, consists in making run-off wastewater, previously decanted on a mass of porous or cavernous materials that serves as support for microorganisms (bacteria) scrubbers. This is why bacterial beds are also referred to as fixed biomass reactors, where biomass is the amount of living matter in an aquatic ecosystem per unit area or volume. Aeration is carried out, usually by natural draw and sometimes by forced ventilation. This aeration is intended to provide the whole thickness of the porous mass with the oxygen necessary for maintaining aerobic bacteria in good working order. Pollutants in water and oxygen in the air pass through the biofilm to assimilating microorganisms, while by-products and carbon dioxide are removed in liquid and gaseous fluids.

The biofilm called "zooglée" or "mucilage" has aerobic bacteria on the surface and anaerobic bacteria near the bottom. This film is broken off and the porous materials are bare, the thickness of the film is automatically reconstituted after three weeks at an average temperature of 25°C, it must be taken into account for this reconstitution of the hydraulic load that varies during the day. The mass of porous materials composed of slag, pozzolan and ash has a small size (2 cm to 8 cm) and its thickness varies from 1,50 m to 4 m. These materials rest on a double deck; the upper deck is generally made of concrete, perforated and the lower deck collects treated water and evacuates it.

The sprinkler at the top of the structure consists of perforated pipes; if the tank is cylindrical, automatic watering is done by a hydraulic turnstile called sprinkler, it has the advantage, by slowly turning, to ventilate the effluent Figure 1 Left.

After the bacterial bed follows the secondary decanter responsible for retaining the sludge «secondary» and send them to the anaerobic digester.

The effectiveness of a bacterial bed depends on:

i. The characteristics of materials used as support for bacteria (porosity, volume area)

ii. The volume and depth of the bed

iii. The regularity of the feed flow

iv. The concentration of organic nutrients (substrates)

Conventional bacterial beds, filled with pouzzolane, often have difficulties in operation due to the clogging of the filter material.

A bacterial bed is defined by its hydraulic charge and its organic charge :[15]

I. The hydraulic charge is the volume of effluent distributed on the bacterial bed, expressed in cubic metres per day and per square metre of filter area

II. Organic charge is the mass of BOD_5 per cubic metre of filter material per day at 20°C

If the flow rate of the bacterial bed is reduced, that is to say 3 m^3 to 4 m^3 per square meter of filter, one is in the presence of a low hydraulic load bed and the organic load in BOD_5 per cubic metre of material is 0,1 to 0,4 kg/d, or on average 0,2 kg/d, which corresponds to the BOD_5 of effluent of 5 inhabitants-equivalents per square metre of bed. Note that the low hydraulic load bacterial bed system is rapidly clogged and the current trend is to use this type of bed only in rare cases Figure 1 Right. The preferred method is high hydraulic load bacterial beds where there is a high water flow through recirculation. Thus, since there is no need to worry about clogging, the bed can be self-cleaning Figure 1 Right. In this case, the sludge is discharged to a secondary decanter. In beds with high hydraulic load, the water content varies from 20 m^3 to 40 m^3 of waste water per square metre of filter per day; the organic charge in BOD_5 per cubic metre of material is 1 to 3 kg/d corresponding to an effluent of 20 to 60 inhabitants-equivalents. It is worth noting that the bacterial bed stream is not very sensitive to transient hydraulic overloads and therefore offers a more consistent quality of treated effluents.

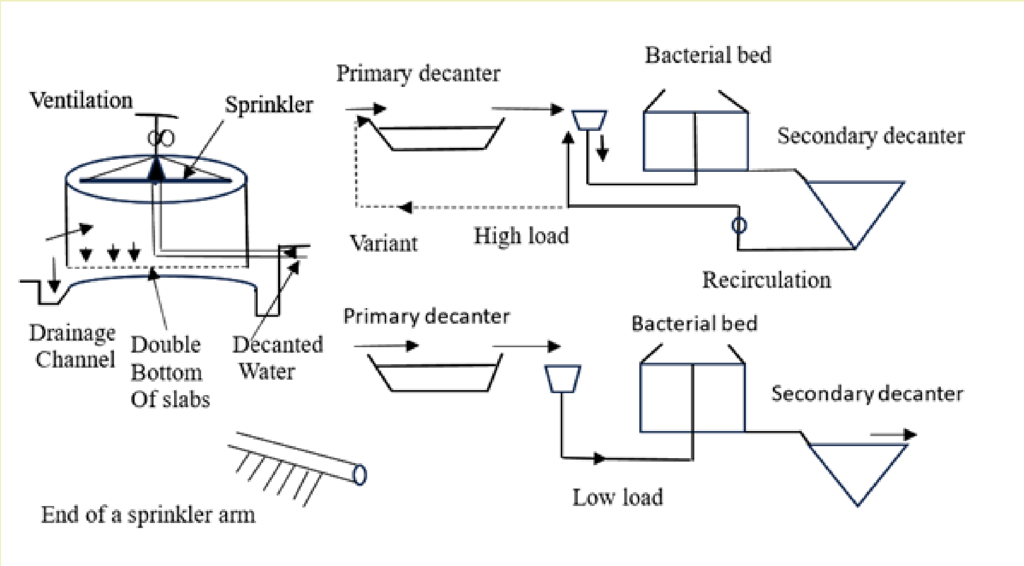

Figure 1 Left: Percolating bacterial bed
Figure 1 Right: Bacterial bed diagrams showing a high-load installation and a low-load installation

Activated sludge

This is a very common method of purification Figure 2. Its a technique which is nothing more than an artificial acceleration of the processes of self-purification in natural environments. In a continuous stream of waste water, aerobic bacteria are subjected to the prolonged action of strong oxygenation obtained by an introduction of air evenly distributed in the effluent; These bacteria absorb organic matter and form large flakes which decant, which in turn constitute sludge or floury masses called activated sludge.

The activated sludge of good quality has a light reddish-blonde colour. These flakes, constantly renewed by a continuous circulation, ensure the rapid degradation of putrescible materials in a much shorter time than in the natural environment.

This bacterial population, which is highly varied in quantity and quality, is sensitive to many factors, namely:

I. The relationship between food and bacterial population

II. The nature of the feed provided by pollutants (biomass)

III. The oxygen content of raw water in the basins

IV. The temperature and pH water

V. Interactions between bacterial varieties

The best method of feeding is to obtain a very fine mixture of sludge and effluent. The elimination of pollution is maximum during the first minutes of sludge contact- releases corresponding to the emergence of adsorption and flocculation phenomena of organic matter. It has been found that 30% to 45% of the biomass of activated sludge is used for efficient denitrification of raw water.

The quality of pollutants used as food by microorganisms plays an important role, because if low concentrations of nitrogen and phosphorus are observed, sludge tends to be abundant, this swelling symptom is the consequence of a certain sludge disease called "bulking".[16]

In practice, the activated sludge process consists of mixing and stirring the raw sewage effluents with these liquid activated sludge, bacteriologically very active, and this with a proportion of 15% activated sludge. It should be noted that these sludge s retain their intense metabolism through sufficient artificial aeration, promoting intimate contact with all parts of the effluent for a specified time.

To obtain the most intense rate of biological oxidation, a minimum oxygen concentration of 0,5 mg/l is necessary in order to achieve the oxidation of organic matter in the aeration basin, and 2 mg/l is required to obtain nitrification of nitrogen substances.

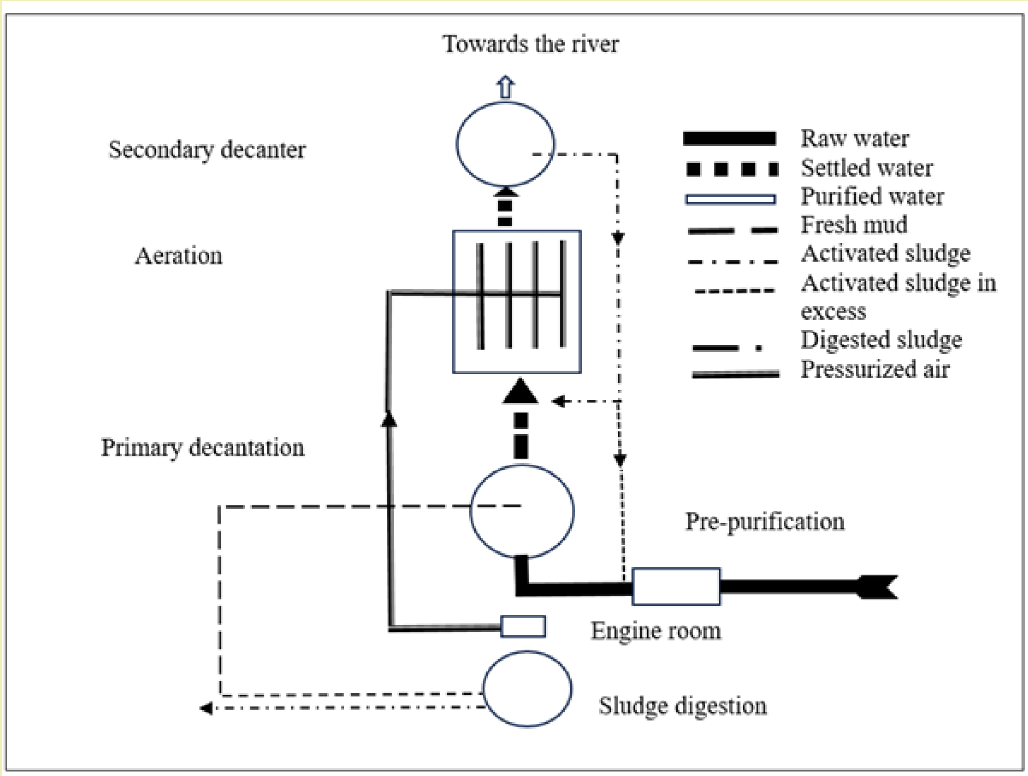

Figure 2: Biological purification: principle diagram of activated sludge purification

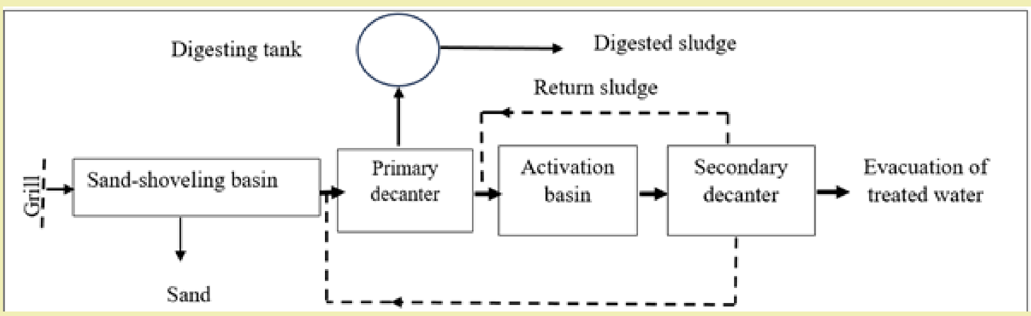

Figure 3: Schematic of activated sludge treatment plant

The installation of an activated sludge treatment plant includes successively Figure 3:

a. Upstream, the preliminary and primary treatments mentioned above

b. The activation pool (or aeration pool)

c. The secondary decanter with recovery of a part of the sludge (15%)

d. The disposal of treated water

e. The digester for excess sludge from primary and secondary decanters

The activation basin, where wastewater and activated sludge arrive, can be considered as a privileged place for the production of bacteria which are used to purify the water. This process is also facilitated by mechanical water agitation or compressed air blowing devices. This brewing requires an air volume of 1m3 to 2m3/inhabitant/ day. The brewing and aeration of the effluent by compressed air through perforated pipes results in the formation of air bubbles within the liquid. Systems with large air bubbles (> 6 mm) or with small air bubbles (< 3 mm). The former prevent clogging, the latter ensure a better homogenization of the air-water mixture. It seems that diffusion by fine bubbles is appreciated in large installations; it is obtained by means of porous plates or domes. The aeration time is 1 to 3 hours to transform most of the organic matter into sludge. The activated sludge processes have some disadvantages, or even impossibilities, resulting from the incompatibility of the life of microorganisms with the nature and quality of the effluent (chemical, ambient temperature in aeration tank, purity of air infused or sludge recycling flow rate). They require very severe monitoring that is incompatible with small stations, but may be well suited for large stations where operating personnel are specialized in the operation of these facilities. It should be recognized that, when the required conditions are met, the efficiency of activated sludge processes is universally appreciated and excellent performance can be found in well-run plants.[17,18]

Thus, in moderately polluted urban waste water (150 mg/l < BOD_5 < 350 mg/l), after good clarification, a treatment yield of BOD5 of the following can be achieved:

a. Prolonged aeration at low mass load = 95%

b. Prolonged aeration at medium mass load = 90%

c. Prolonged aeration at high mass load = 85%.

The viral concentrations found in urban wastewater before treatment range from 10 to 10 000 infectious units per litre of raw water. The treatment of these waters with activated sludge allows to retain 55% to 95% of this viral load.

Tertiary Treatments

Once the reuse of urban waste water is defined, tertiary treatment is chosen according to the quality characteristics of the water to be treated. The complexity of secondary effluent quality is often very high, variable, and it is known that pathogenic microorganisms retain their virulence. So we understand why the complementary treatment can present difficulties of implementation, even impossibilities, if one introduces the cost prices which can, in some cases, be prohibitive.

The possible solutions involve types of processing which may be classified as follows:

a. Physical: decanting, filtration, sieving, micro-filtration

b. Chemicals: lime based, flocculation, nitrogen and phosphorus extraction

c. Biological: lagoons, activated sludge, discharge into the soil

d. Bacteriological: by the use of chlorine, chlorine gas, chlorine dioxide, chlorine-bromine mixture, or ozone, by adsorption with activated carbon or fly ash and ultraviolet radiation

These types of difficult and costly treatment are currently being implemented in very special cases, but the principle of water regeneration can be applied on a large scale if better protection of the natural environment is to be achieved, and in particular to encourage the taking of drinking water from rivers or reduce prohibitive costs for supplying water to the inhabitants of a city, when these works require the costly construction of a very long network.

The following are some of the tertiary treatment processes which may be used:

A. Filtration on materials such as bottom ash, gravel and sand and may also be active coal, in order to reduce suspended matter, avoid clogging; filtration is recommended to improve the adaptation of water intended for groundwater recharge

B. Chemical, physical or biological treatment, which is of interest when river water is used for the food supply of inhabitants; the following methods are then used:

   a. Precipitation by lime

   b. Artificial ventilation

   c. Chlorination, bromine or ozonation

   d. Laguning systems, where available land permits

   e. Finally, sterilization for the rapid destruction of pathogenic microorganisms, especially if effluents come from hospitals or slaughterhouses

Disinfection of effluents by chlorination or bromine

After conventional biological or physico-chemical treatments, it may be necessary or even essential to sterilize waste water before discharge. This is the case for certain waters suspected of containing pathogenic microbes or urban wastewater discharges that occur near a water intake for drinking water supply, bathing, beaches, fish farms or shellfish farming.

However, disinfection treatments may only aim to eliminate a portion of the pathogenic germs. The oxidant power of chlorine is used with a contact greater than 15 min at peak flow rate. To achieve a 99,9% reduction in coliform, the doses allowed are as follows:

a. After bacterial beds: 3 to 10 mg/l

b. After activated sludge: 2 to 8 mg/l

c. After sand filtration or activated charcoal: 1 to 5 mg/l

The more water is loaded, the less effective chlorination is. Decantation is therefore an important criterion to observe.

The chlorination is a tertiary treatment solution, antipollution and antibacterial, which is recommended when the infectious risks of a region or sector are significant. Brominated wastewater disinfection may be considered; brominated water is prepared by dissolving liquid brome in the water. However, avoid handling liquid bromine as it releases dangerous suffocating fumes.[19]

Ozone disinfection of effluents

The passage of high-voltage electrical effluent through dry air results in the formation of ozonised oxygen, with an ozone (O_3) content of about 10%. Ozone O_3 is always used in a solution diluted in a gas (oxygen, air). It takes 9,5 to 14 mg/l of ozone injected for 20 min to achieve a very satisfactory disinfection. The Ozonation treatment is carried out in contact columns where water and ozone air circulate intensively against the current to obtain a real mixing of fluids. Very often ozone is used in combination with chlorine gas. This process of disinfection of urban wastewater is used after biological purification of effluents by activated sludge. It is recognized that ozone has a greater efficacy than chlorine, but the mechanism of action of bactericidal disinfectants is still poorly understood. Good results are obtained by ensuring that the ratio of water to ozone air flows is as constant as possible. Minimum ozones valus of 1 to 2 mg/l after 20 min contact time result in a maximum concentration of 103 fecal coliforms per 100 ml, which is an acceptable disinfection.

Conclusion

Today, under the pressure of economic and ecological constraints, urban waste water treatment techniques, sludge recovery problems and rigorous quality of discharges, mark a certain evolution of the processing lines and an awareness in order to ensure the simultaneous good functioning of the networks and stations; the tasks of technical management of facilities are indeed recognized as very important for the proper functioning of a sanitation service.

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Conflicts of Interest

Regarding the publication of this article, the author declares that he has no conflicts of interest.

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