International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 11 Issue 11, November-2022, Impact Factor: 7.957

Pathogen and nutrients removal from wastewater using multistage biofilters

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ABSTRACT

Wastewater is water that must be treated before it's discharged into another body of water. Some wastewaters are tougher to treat than others. the most thing about pollution is human intervention. Treatment is needed to safeguard humans also as aquatic organisms from harmful diseases like epidemic cholera and enteric fever. every receiving body of water features the most amount of contaminants that it will tolerate while not deteriorating. As a result, every biodegradable pollution treatment facility should have an allowance that specifies the utmost quantities of BOD5, suspended particles, E. coli, and different pollutants that may be discharged. It's viable that each living reality on Earth is infected or parasitized in some manner. The factor of sewer water treatment is to get rid of as vital junk as doable before eliminating the redundant water, appointive as effluent, back to the piece of land. The objective is to decrease or eliminate pollutants while also killing disease-causing organisms. Each receiving body of water has a maximum quantity of contaminants that it can tolerate without deterioration. The factor is to drop or decimate pollutants whereas mentioning complaint-causing organisms.

Keywords: Wastewater, pathogen, biofilters, nutrients

INTRODUCTION

Wastewater is water that must be treated before it is discharged into another body of water to prevent additional contamination of water sources (2). Diverse sources produce wastewater. Wastewater is everything that you simply flush down the toilet or pour down the drain. Rain and runoff, along with different pollutants, flow through street gutters and eventually find you at a wastewater treatment facility (8). Agricultural and industrial sources also can produce wastewater. Some wastewaters are tougher to treat than others; for instance, industrial wastewater could be challenging to handle while domestic wastewater is generally straightforward. the most factor in water pollution is human intervention. Small and large-scale companies discharge their waste products into the water, which include chemical and biological waste, also as hospital waste. The presence of those elements in the water is also a hazard to aquatic life, as their population is decreased since the critical growth circumstances required by them are inhibited by these poisonous components, which cause aquatic life death(11). Because numerous hazardous substances are introduced into the water daily basis, maintaining the water has become the foremost important stage. Numerous physical, chemical, and biologicaltechniques are used, but they're expensive and cannot be applied on a broad scale. a spread of methods has been used to treat wastewater, including activated sludge, induced gas flotation, ultraviolet disinfection, and supercritical water oxidation (SCWO), but these are too labor-intensive, expensive, and time-consuming. Without disposal, waterborne disease pathogens can spread and cause disease. Furthermore, water can't be recycled to meet the needs of a growing population. Thus, this treatment is required to guard humans as well as aquatic living organisms from harmful diseases such as cholera and typhoid. For wastewater treatment, different methods, primarily activated sludge, induced gas flotation, ultraviolet disinfection, and supercritical-critical water oxidation, were utilized (SCWO). These methodologies are time-consumingand inefficient (28).

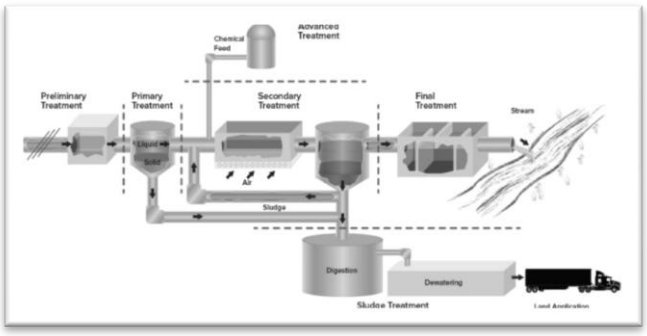


Fig.1: The wastewater treatment process.

Sewage treatment may be a multistage procedure that transforms wastewater before it reaches a body of water or is reused on land via irrigation. Each receiving body of water features a maximum quantity of contaminants that it can tolerate without deterioration. As a result, each sewage treatment facility must have a permit that specifies the utmost quantities of BOD5, suspended particles, E. coli, and other pollutants which will be discharged (26).The following review discusses the discarding of viral, bacterial,protozoan, and helminthic pathogens achievedby the most generally used natural and conventional treatment processes aredetailed, and recommendations are made for process selection.

Table.1: The major diseases and symptoms of wastewater

	Name of the pathogen	**Major diseases or symptoms**
Bacteria	E. coli	Gastroenteritis
	Salmonella spp.	Typhoid, paratyphoid
	Campylobacter jejuni	Gastroenteritis
	Shigella spp.	Bacillary dysentery
	Vibrio cholerae	Cholera
	Yersinia spp.	Gastroenteritis
Viruses	Astrovirus	Gastroenteritis
	Poliovirus	Poliomyelitis
	TT hepatitis	Hepatitis
	Adenovirus	Upper respiratory infection and gastroenteritis
	Coxsackie virus	Meningitis, pneumonia, fever
	Echovirus	Meningitis, paralysis
	Hepatitis A virus	Infectious hepatitis
	Hepatitis E virus	miscarriage, and death
Protozoa	Balantidium coil	Balantidiasis
	Cryptosporidium spp.	Cryptosporidiosis
	Entamoeba histolytica	Acute amoebic dysentery
	Giardia duodenalis	Giardiasis
	Toxoplasma gondii	Toxoplasmosis

Diseases in detail -

Salmonella spp. Typhoid and paratyphoid are spread by contaminated water or food. They can also spread via the fecal-oral route. Water, ice, raw vegetables, salads, and shellfish both are important sources for travelers. Hot food destroys a lot of the germs that cause traveller's diarrhea. Cooked food that is presented steam hot is typically safe to eat. Be cautious with food that's been served and left at room temperature or in a warmer, such as on a buffet. It might get infected while sitting out. Dry or packed foods: Most microbes require moisture to flourish, thus dry foods, such as potato chips, are usually healthy (32).

Vibrio cholera. Cholera is an acute diarrheal ailment caused by a Vibrio cholerae pathogen of the gut. When cholera germs infect water, people might be ill. The infection is frequently minor or without symptoms, while it can rarely be severe and life-threatening. In the presence of autochthonous ultra-microflora cells in stored filtered well water, cholera might survive. Make sure you ingest and use safe water. Brush your teeth, wash and prepare food, and create ice or beverages with bottled water. If bottled water is not available, use water that has been properly boiled, chlorinated, or filtered through a microbe filter. Use bottled water with intact seals.

Shigella spp. Shigella is set up in the coprolite of infected people, in food or water defiled by an infected person, and on shells that have been touched by infected people. Shigellosis frequently occurs in toddlers who aren't completely restroom-trained. During critical periods, precisely wash your hands with cleanser and water. Before engaging in any sexual activity.

Before preparing or consuming meals. After using the bathroom, changing a diaper, or drawing up after another person who used the restroom. When changing diapers, use caution. As soon as you change a diaper, dispose of it in a lined, covered scrap can. Remove any leaks or tumbles from the diaper all the way down.

Campylobacter jejuni. Toxic water is one of the most prevalent causes of Campylobacter. Wild and domestic animals excrete Campylobacter into lakes, gutters, aqueducts, and budgets through feces, thus all water for mortal consumption must be cleaned. Before, during, and after cooking meals. Prior to consuming food. After using the restroom. After changing diapers or pulling up a youngster who has used the bathroom. After touching favorites and other critters, or their food.

Adenovirus. When an infected person coughs or sneezes, adenovirus can spread through droplets. Fecal waste can spread the virus through waste water, dirty diapers, and inadequate hand washing. On surfaces that are effective in killing adenoviruses, apply an EPA-registered disinfectant, such as a bleach-based solution. Ensure that the disinfectants remain on all surfaces for the provided period. Allow drying while soaking wet. TT hepatitis. The most common occupational danger for wastewater workers is direct contact with a range of infectious agents contained in sewage debris, with hepatitis A virus being the most common.

Coxsackie virus. It is possible to become infected with the coxsackievirus from a lake, but even this becomes less likely. Despite their viral nature, the vast of coxsackievirus species are totally harmless. The most incidence of ulcerative pharyngitis is Coxsackievirus. Ulcer-like sores would appear in the mouth, frequently on the palate. Sanitary measures can be used to keep it contained. The best defenses involve general cleanliness, frequent hand washing, and eliminating toxic water (32).

Balantidium coli is an intestine protozoan parasite that causes the infection balantidiasis. While this type of illness is uncommon in humans, other mammals can become infected with Balantidium coli by ingesting infective cysts from contaminated food and water. Balantidium coli infection can be avoided by practicing excellent hygiene when traveling. After using the lavatory, changing diapers, or handling food, wash your hands with soap and warm water. Teach children the significance of hand washing to prevent infection.

Nutrient

Nutrient excess is harmful to the environment. They can pollute water in rivers, lakes, and estuaries, as well as oxygen dead zones, fish kills, and harmful algal blooms (23).

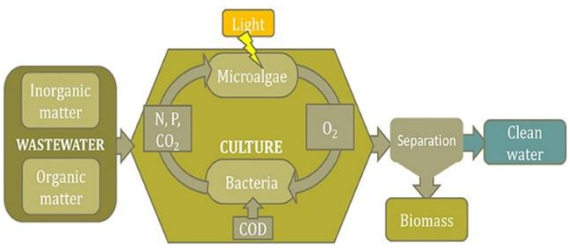


Fig.2: Nutrients removal treatment

Total nitrogen and total phosphorus are eliminated from wastewater using microorganisms under a variety of circumstances during the treatment process.

Nitrogen and phosphorous are necessary for the development and vitality of living creatures and are hence referred to as nutrients. However, the release of nutrient-rich industrial effluents into aquatic habitats causes eutrophication (11). As a result, nitrogen removal from sewerage is critical to meeting the high nutrient discharge regulations.

The addition of harmful nutrient compounds in public wastewater treatment plant outflow, especially nitrogen and phosphorus, induces cultural eutrophication in surface bodies. Season aquatic plants are a common example of eutrophication, and they may affect things for both ecosystems and people, including low oxygen, fish kill, murky water, and the depletion of desired flora and fauna (18). Because conventional biological techniques developed to fulfil secondary treatment effluent requirements do not often remove total nitrogen and total phosphorus to the extent required to maintain receiving waterways, wastewater management facilities are increasingly being forced to develop methods that lower effluent levels of nutrients to safe levels.(13) This can be difficult for wastewater treatment facilities because it generally requires large process changes, such as leaving a section of the anaerobic process anaerobic or anoxic, which lowers the aerobic volume and restricts nitrification efficiency.

Role of Microalgae

As a by-product of wastewater treatment, microalgae produce oxygen, which aerobic bacteria use to break down the residual organic loads. As compared to the cost of mechanical energy for aeration during conventional wastewater treatment, this conserves energy. Aside from standard wastewater treatment practices, algae are also utilized as an essential bioremediation agent in many wastewater facilities. (12) It is becoming more common to reuse biomass captured during wastewater treatment while also including CO2 sequestration, BOD balancing, and nutrient removal. Lipases and absorption of macronutrients and micronutrients, such as trace and heavy metals in wastewater, are part of microalgae metabolism.However, the strains were always selected based on their wastewater tolerance, nutrient intake capacity, and growth. In well-aerated cultures, the dominating type of micro has always been coccoid microalgae, which are not quickly grazed up until the climax of the culture (1). Microalgae require light, CO2, and inorganic nutrients such as nitrogen and phosphorous (N and P) for growth and development.Chlorella, Scenedesmus, Synechocystis, Gloeocapsa, Chroococcus, Anabaena, Lyngbya, Oscillatoria, Spirulina, and other common microalgae taxa are favored for physio-remediation and subsequent biomass usage for food, feed, and fuel. Algae surpassed other phytoremediation entities due to its rapid growth in confined spaces and viability in contaminated water using a variety of nutrients (10).

LITERATURE AND REVIEW

Table.2: Literature and reviews of wastewater treatments

Name	Technique	Methods	Result
Removal of Escherichia coli from synthetic stormwater using microfiltration	Power-tested microfiltration media	The immersion of E. coli in and out of Stropharia rugosoannulata biofilters. Three-dimensional remediesare shown influence pollutants, power-tested microfiltration media, and power-tested microfiltration media. contaminants are tested at both low and high inflow conditions. Typical E. colimedium value includes error bars.	It was initially overwhelmed withsynthetic rainwater without E. coli, wastes from every biofilter export bacteria tested for coliform is thermotolerant, however, it is a very different level.
Nitrogen and Phosphorus Removal from Sewage in Biofilter	Activated Sludge Combined System		Based on a statistical study of the info treated wastewater didn't mix with usually phosphorus-concentrated conditions emerging from the licensing of the general nitrogen treatment facility under the purpose of water regulation.
Biofilters as effective pathogen barriers for greywater reuse		The first use of biofilters to get rid of germs from Greywater was tested for a year for various	Previously, system maturity has been reported to enhance everything operating to

		design materials and performance limits. supported the results, studies from this study are often safely applied in the future purposes of light greywater reuse with biofilters for housekeeping.	remove microorganisms by performing closure layer or creating microbial community within biofilters after the operation.
A review of posttreatment technologies for anaerobic effluents for discharge and recycling of wastewater	DHS technique	All micropollutant identification is complex, and no holistic solution has been developed; although, with the rising use of recent analytical techniques, the identification of those molecules is progressing rapidly	Postoperative rehab for discharge standards has been studied widely, and DHS was fully operational medicinal plants scale. Genetic removal of nutrients (N and P) should be considered not just for levels of release or reuse but also for the detection of these nutrients.
A Review Of Research On the Application Of Trickling Filters In the Removal Of Various Pollutants From Effluent	Trickling Filters	utilizing trickling filters to filter various toxic compounds. In trickling filters, microorganisms in wastewater attach themselves to a germ-infested bed. They underline the necessity of identifying the harmful environmental impacts of toxic water that hasn't been properly prepared or access to the coastal environment that has not been adequately prepared, especially in lives that depend on the natural system for survival	A gradient bed and citrate renewal were used. Wastewater from mining, textile, and other areas has been treated correctly, removing toxic compounds.
Review on Slow Sand Filtration in Removing Microbial Contamination and Particles from Drinking Water	Sand Filtration	They utilize gradual sand filtration to get rid of the dust from water in chemical, physical, and biological forms. a serious part impacting the trying to separate filtering sand is the cleaning level. additionally, sedimentation and biological processes are suffering from the degree of membrane separation.	Slow sand filtering has been identified as an efficient beverage treatment technique in rural areas, also as an effective filtration technology for removing germs found in water and reducing turbidity.

Treatment strategies

Electrocatalysis is a chemical technique that involves oxidation and reduction reactions by direct electron transfer and needs electrocatalytic to lower the overpotential of the actions (3).

Ti/RuIrO2 electrode is utilized as the anode and a stainless-steel plate is used as thecathode in a full-scale electrocatalytic converter that is created of six tubes (1.2 m3) to treat runoff during actual batik printing.

Electrospinning is the most typical method for making nanofibers. Due to their distinctive qualities including being environmentally friendly, biocompatible, and biodegradable, nanofibers made of natural polymers are currently finding use in a variety of fields including medicine, fuel, water treatment, etc. Aside from these features, nanofiber mats for purifying water should be energy-efficient, which can be obtained if the chemicals and structure-property interactions can be regulated in such a method that electrospinning optimizes the composition, morphology, and even secondary structure.Activated carbon, reverse osmosis, mixed media, and UV filters are the most used systems. Most systems, however, utilize a mix of these methods for optimal filtration. Furthermore, the sort of system that is best for a building is based on the quality in the region.

Substance, thermal, biological, and mechanical methods can be used to treat hazardous waste. Ion exchange, dissolution, redox reactions, and neutralization are all chemical methods. High-temperature incineration is a thermal process that might not only cleanse but also destroy certain organic wastes (21).

Filtration mediated by biomass in water treatment Biomass may eliminate contaminants from wastewater while also reducing, recovering, and reusing trash.

Chlorella Sorokin Ana and Lemna minor removes the COD,TKN NH4-N, and PO4-P via SBR

Water resource management. DSSs have been usually applied in water resource management to assist decision-making regarding competing demand from potable water.

Often used to identify the preliminary, major, secondary, and tertiary treatment for patients.

Electro coagulation is a useful method of treating several types of wastewater and leachate. It has the ability to remove an assortment of contaminants, including chemical oxygen demand, turbidity, ammonia, colour, and suspended particles

Electro coagulation is composed of pairs of metal plates called electrodes that are organized in pairs of two—anodes and cathodes. Using electrolytic principles, the cathode is oxidized while the water is reduced, resulting in better wastewater.

As a result of wastewater treatment, microalgae give off oxygen, that aerobic bacteria are using to break down the organic volatile loads. This lowers the energy cost as compared to the cost of mechanical energy for circulation during standard wastewater treatment.

Microalgae play a key role in aquatic environments by cycling resources, fixing inorganic carbon into biological substances, and expressing oxygen.

Multibiofilters

Biofiltration systems are typically resilient, simple to build, and use less energy. Sand filtration, biological activated carbon (BAC) filtration, riverbank filtration, and regulated groundwater resources are the most used often techniques. A BAC filter is made out of a stable bed of granular activated carbon (GAC) that permits bacteria to grow on its surface. This method has been used for many years for drinking water treatment, generally the following ozonation, and has proven to be efficient at removing natural organic matter, ozonation by-products, DBP precursors, as well as taste and odour elements (25).

Activated carbon –

Activated carbon was the first widely used adsorbent. The use of activated carbon is perhaps the best broad-spectrum technique currently available to lessen the contamination of water by organic substances. Because it has a high affinity for binding organic materials even at low concentrations, activated carbon is an effective adsorbent. It contains a vast network of various size pores that can take both giant and micro contaminant molecules, making activated carbon a fairly large surface area(12). The majority of the total surface area is considered to be of the planar surface type with few attached functional groups, and hence the majority of the adsorption on the surface is assumed to be due to the fairly weak mechanical forces.

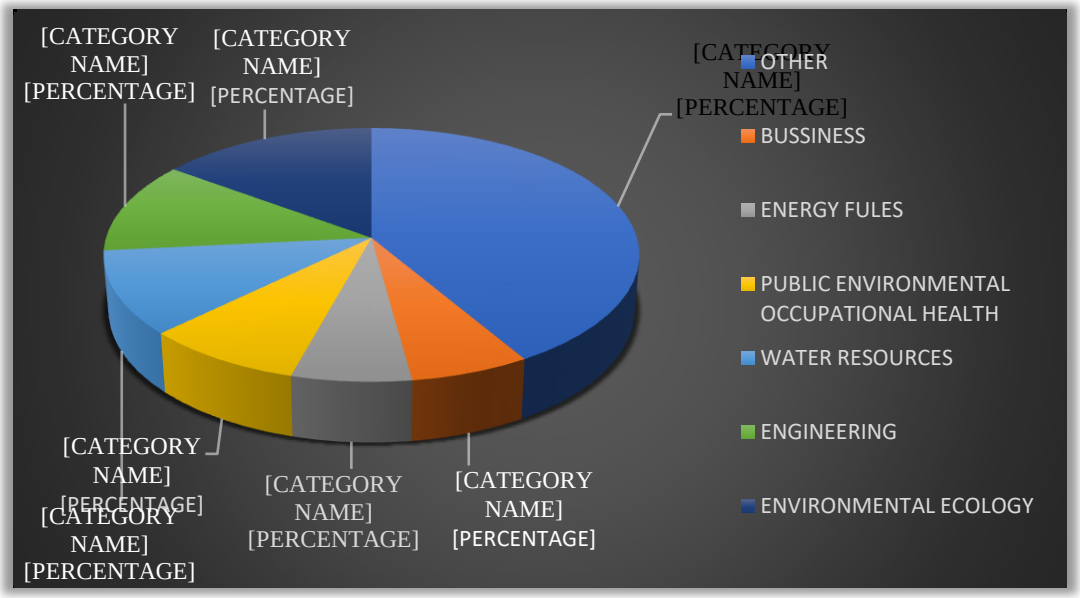


Fig.4: Source of wastewater (Pie chart)

Biological filters –

Biological filtration generally termedbiofiltration is a water treatment method that may rapidly remove organic matter from the water and biologically treated sewage effluent that is not extracted through conventional sewage systems. The biological filter is mainly reliant on the activities of the group of microorganisms linked to the biofilter. The functionality of biological filtration is governed by microbial activity (9). Since microbes burn organic materials to generate energy, available nutrient sources in feed water are critical for their growth. Furthermore, elements such as hydraulic loading rate, back washing procedures, temperature, pH, and others, may regulate biomass growing on GAC in the biofilter. Moreover, biological filtration is both cost-effective effective, and eco-friendly.A biofilter is any type of filter that has attached biomass to the biofilter. It could be a trickling filter in a wastewater treatment plant, a horizontal rock filter in a polluted stream, or a water treatment facility's granular activated carbon (GAC) or sand filter. A biofilter has been successfully used for air quality, water, andwastewater (25).

Biological filtration using granular activated carbon (GAC) is a viable treatment for drinking water. Despite its large adsorption capacity, GAC can only sustain adsorption for a short period of time in a biofilter before its adsorption capacity is exhausted, resulting in lower treatment effectiveness. GAC may be regenerated using a variety of methods, involving thermal, hydrothermal, chemical, and ultrasonic regeneration. However, regeneration usually reduces GAC adsorption capacity and requires a lot of energy. Exhausted GAC can also be utilized as support filter material for biological filtration. GAC offers a large area for microorganism growth and development in the biofilter (3). Moreover the, due to some of the operational drawbacks of the biofilter, such as performance fluctuation, biomass maintenance, and disinfection adequacy of such biofilter effluent, research on the biofiltration process has become crucial.

Table.4: The water and sewage biofiltration system

Filter medium	Experimental		Major observation
GAC	DOC, DO, NH3, NO,	Bacterial count	Deactivating the biofilter promotes anaerobic conditions, reducing the effluent quality. When microbial activity occurs, the biofilter should be backwashed.
Anthracite sand	AOC-NOX, NPOC, Turbidity	HPC	The backwashing technique and hydraulic transient both can get an impact on biofilter performance.
Granit blast furnace slag	BOD, ammonia, SS	None	The performance of a biofilter is determined by the rate of organic loading, the temperature, and the filter design configuration.
Anthracite+ sand, GAC+ sand, sand	TOC, BDOC, aldehydes, AOC-NOX, THM, and TOX formation potential	Phospholipid analysis	GAC had 3-8 times the biomass of sand or anthracite.

AOC -Assimilable organic carbon
BDOC-Biodegradable dissolved organic carbon
NOX-Nitrogen oxide
NPOC-Non purgeable organic carbon
BOD-Biochemical O2 demand
SS-Suspended solid

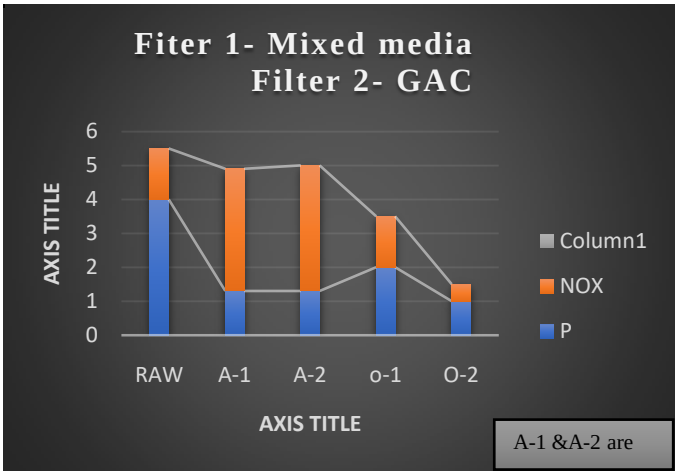
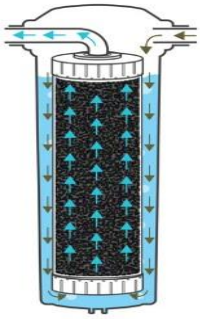


Fig.5:Evaluation of filters

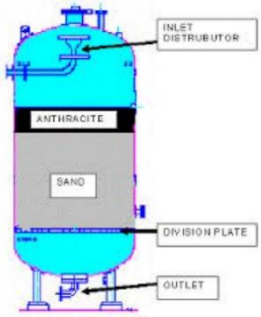
Filtration used in multibiofilters

GAC (Granular activated carbon)-Granular actuated carbon is manufactured from high-carbon organic source accoutrements. It's critical to know the kind and attention of adulterants, as well as the normal water operation, in order to estimate the applicable system size and factors. All treatment systems bear applicable installation and conservation on a regular base (4). The determining GAC filter is to use the kind and quantum of adulterants in the water, other chemicals in the water, water use, and exposure paths must all be removed.



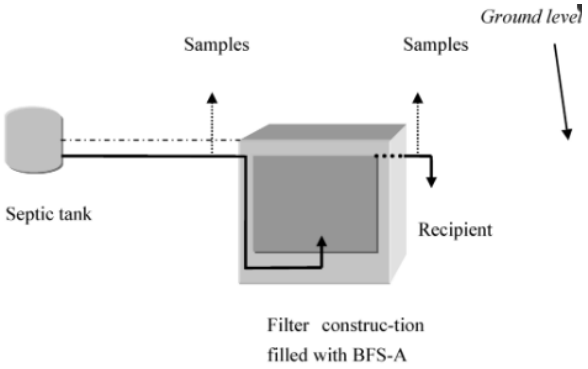
GAC

Anthracite media is substantially used for water filtering and wastewater treatment. It provides advantages similar to lesser service inflow rates, longer sludge runs, lower outcome rates, lower head loss, and generally increases the life of the sludge beds.



Anthracite filtration

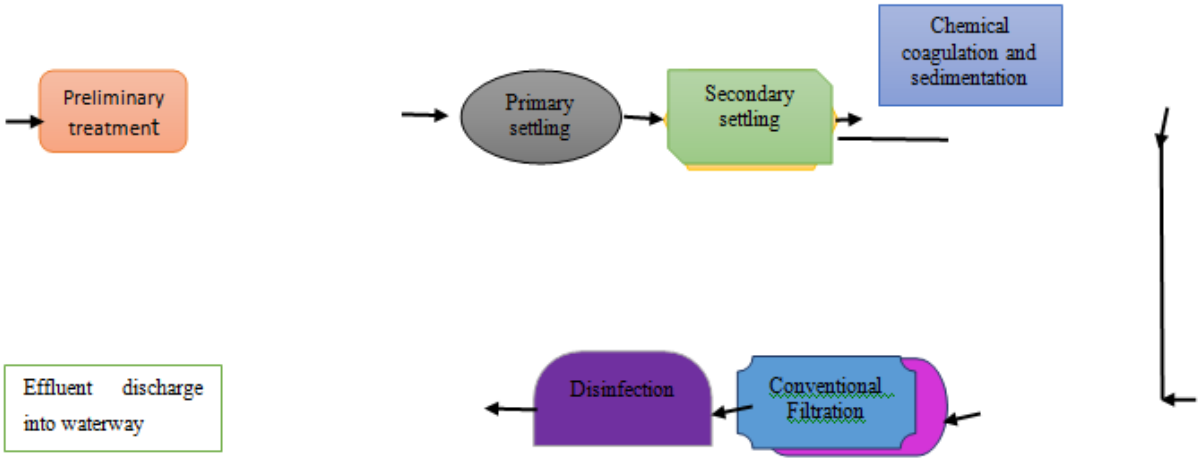
Blast furnace sediment is a derivate of sword manufacturers. The thing of this study was to examine advanced styles for assessing the phosphorus sorption capacity of BF sediment. The operation of BF sediment before use and congesting were also studied, as was calculating the phosphorus retention capacity(25).



Granit blast furnace slag

Anthracite+ sand, GAC+ sand, sand-By virtue of the unique form of its grains, it allows suspended particles to be maintained in the filtering bed's depth. In comparison to a sand filter, this filtering substrate provides greater flow, less pressure drop, and better and faster backwash.

The strength of microbial attachment to a sample is determined by environmental conditions, the type of microorganisms, surface characteristics, and fluid properties (28).



Flowchart of biofiltration formation

CONCLUSION

Nutrients and pathogens are vital for life on Earth. However, eliminating them from waste streams is also crucial for mitigating the environmental problem of the eutrophication of receiving bodies of water.Furthermore, knowledge of pathogen forms and expected quantities in local wastewater is necessary to ensure that the specified technique is capable of inactivating or removing them efficiently. It is also necessary to evaluate the quantity and quality of sludge generated during wastewater treatment, as well as how it will be disposed of. After treatment, it can be utilized to substitute freshwater in irrigation, industrial operations, and recreation. It may also be utilized to keep the environment working, and the by-products of its treatment can provide energy and nutrients. This paper presents an exhaustive review of processing technologies that will meet the goal of recovering Nitrogen, Phosphorus, and pathogen from a waste stream.

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