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Wastewater Treatment System

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Abstract: Wastewater is water that has been used and must be treated before it is released into another body of water, so that it does not cause further pollution of water sources. Wastewater comes from a variety of sources. Everything that you flush down your toilet or rinse down the drain is wastewater. Rainwater and runoff, along with various pollutants, go down street gutters and eventually end up at a wastewater treatment facility. Wastewater can also come from agricultural and industrial sources. Some wastewaters are more difficult to treat than others; for example, industrial wastewater can be difficult to treat, whereas domestic wastewater is relatively easy to treat (though it is increasingly difficult to treat domestic waste, due to increased amounts of pharmaceuticals and personal care products that are found in domestic wastewater.

Key ward: Wastewater · River · BOD · COD · Tretment

INTRODUCTION

When you think about the variety of materials that enter the wastewater system from a typical home, the list is diverse and extensive: wastes from toilets; soap, detergents and cleaning products from drains and washing machines; food items from garbage disposals-all along with large quantities of water. How is this material removed so that the water may be safely returned to the environment and, possibly, utilized again by other people downstream? [1] The answer depends on where you live. If your home is not serviced by a public sewer system, your wastes are undoubtedly treated with a septic system. In this system, wastes

Responsible for Making Sure That Wastewater: Similar to drinking water provisions, the federal government has delegated responsibility for wastewater treatment to the provinces and territories. There are two federal acts, however, that may apply to wastewater. The Fisheries Act prohibits the release of harmful substances into waters that fish live in. The Canadian Environmental Protection Act governs the release of toxic substances into the environment and allows the federal government to develop regulations for the use of toxic substances.

Most provincial and territorial governments have legislation regarding wastewater treatment standards and requirements. Operators of wastewater treatment facilities must obtain permits or licenses from the provincial or territorial government and these permits may also require additional treatments or limits on effluent discharges. For example, in British Columbia, all municipalities are required to have a Liquid Waste Management Plan; without an approved plan, discharges are illegal. Provincial and territorial governments generally assist municipal governments with funds to build and maintain infrastructure [2].

Municipal governments directly oversee the wastewater treatment process and are able to pass additional by-laws. For example, the Regional Municipality of Ottawa-Carleton has developed a program to eliminate toxic substances from the wastewater treatment system, requiring all industrial, institutional and commercial facilities to limit the amount of certain pollutants that are allowed into sewers [3,4].

Treat Wastewater: There are several levels of wastewater treatment; these are primary, secondary and tertiary levels of treatment. Most municipal wastewater treatment facilities use primary and secondary levels of treatment and some also use tertiary treatments. The type and order of treatment may vary from one treatment plant to another, but this diagram of the Ottawa-Carleton wastewater treatment plant illustrates the basic components.

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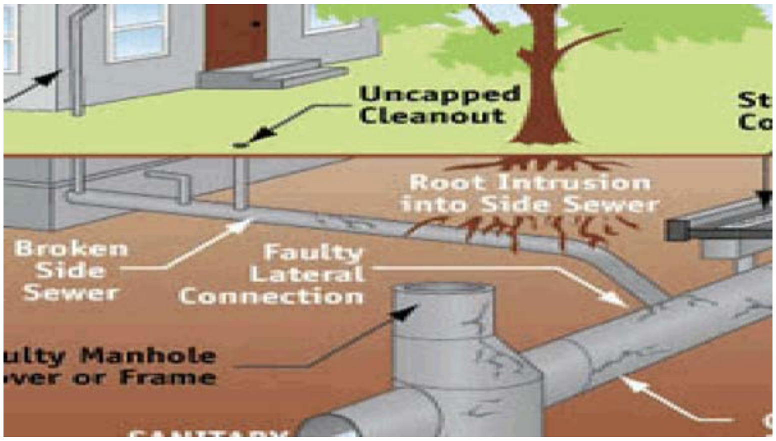

Fig. 1: A side sewer connects the house to the local sewer line in the street. Maintenance of a side sewer is the property owner's responsibility.

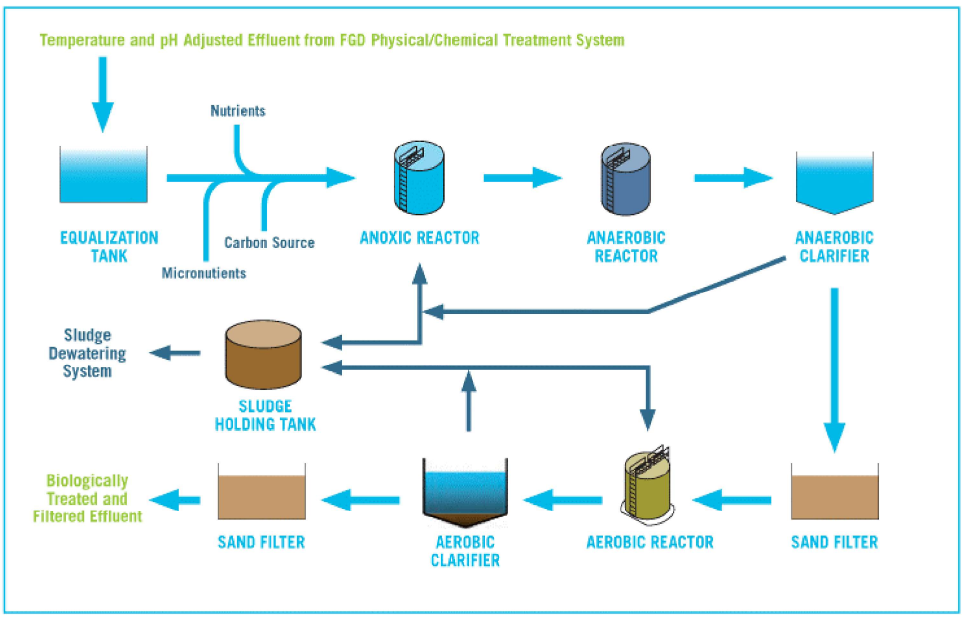

Fig. 2: Treatment System integrates biological reactors with Degremont clarifiers and sludge thickeners to treat effluent from a FGD physical/chemical wastewater treatment system for the removal of nitrates, heavy metals, ammonia and biochemically oxidizable organics measured as the Biochemical Oxygen Demand (BOD).

The primary level of treatment uses screens and settling tanks to remove the majority of solids. This step is extremely important, because solids make up approximately 35 percent of the pollutants that must be removed. The screens usually have openings of about 10 millimetres, which is small enough to remove sticks, garbage and other large materials from the wastewater. This material is removed and disposed of at the landfill [5.6].

The water is then put into settling tanks (or clarifiers), where it sits for several hours, allowing the sludge to settle and a scum to form on the top. The scum is then skimmed off the top, the sludge is removed from the bottom and the partially treated wastewater moves on to the secondary treatment level. The primary treatment generally removes up to 50 percent of the Biological Oxygen Demand (BOD; these are substances that use up the oxygen in the water), around 90 percent of suspended solids and up to 55 percent of fecal coliforms. While primary treatment removes a significant amount of harmful substances from wastewater, it is not enough to ensure that all harmful pollutants have been removed.

Secondary treatment of wastewater uses bacteria to digest the remaining pollutants. This is accomplished by forcefully mixing the wastewater with bacteria and oxygen. The oxygen helps the bacteria to digest the pollutants faster. The water is then taken to settling tanks where the sludge again settles, leaving the water 90 to 95 percent free of pollutants. The picture below shows the settling tanks in the Winnipeg Wastewater Treatment Plant. Secondary treatment removes about 85 to 90 percent of BOD and suspended solid and about 90 to 99 percent of coliform bacteria [7, 8].

Some treatment plants follow this with a sand filter, to remove additional pollutants. The water is then disinfected with chlorine, ozone, or ultraviolet light and then discharged. For more information about any of the steps of the water treatment process.

The sludge that is removed from the settling tanks and the scum that is skimmed off the top during the primary steps are treated separately from the water. Anaerobic bacteria (anaerobic bacteria do not require oxygen) feed off of the sludge for 10 to 20 days at temperatures around 38 degrees Celsius. This process decreases the odour and organic matter of the sludge and creates a highly combustible gas of methane and carbon dioxide, which can be used as fuel to heat the treatment plant. Finally, the sludge is sent to a centrifuge, like the one shown in the picture below. A centrifuge is a machine that spins very quickly, forcing the liquid to separate from the solid. The liquid can then be processed with the wastewater and the solid is used as fertilizer on fields.

Tertiary (or advanced) treatment removes dissolved substances, such as colour, metals, organic chemicals and nutrients like phosphorus and nitrogen. There are a number of physical, chemical and biological treatment processes that are used for tertiary treatment. One of the biological treatment processes is called Biological Nutrient Removal (BNR). This diagram shows the treatment steps that Saskatoon wastewater goes through.

In this treatment plant, wastewater first undergoes primary and secondary treatment. For the tertiary treatment, the BNR process occurs in the bioreactors. The BNR process uses bacteria in different conditions in several tanks, to digest the contaminants in the water. The three tanks have unique environments, with different amounts of oxygen. As the water has passes through the three tanks, the phosphorus is removed and the ammonia is broken down into nitrate and nitrogen gas, which other bacterial processes can not do. The BNR process can remove over 90 percent of phosphates, while traditional processes remove much less than 90 percent. The water spends approximately nine hours in the bioreactors, before entering the secondary clarifier, which is a settling tank, where the bacteria-laden sludge settles to the bottom of the tank [5].

Small Communities Treat Wastewater: In small communities, wastewater treatment facilities may consist of individual septic systems, simple collection systems that directly discharge effluent to surface waters, or municipal lagoons that are emptied annually. These facilities usually treat and disperse the waste as close as possible to its source, thus minimizing operational costs and maintenance requirements. The longer the waste can sit in a lagoon before being discharged, the less likely it will be to contaminate drinking water sources. Some communities store the waste in lagoons, but others release the waste directly into water sources.

Lagoons are reservoirs in the ground that store waste for a time until it is discharged, either to the soil or a water body. Shallow lagoons, that are less than 1.5 metres deep, are used for primary treatment, which allows the solid waste to settle to the bottom of the lagoon over a period of 6 to 20 days. Shallow lagoons, however, cannot effectively remove the majority of contaminants that pose problems for ground and surface waters. Deep lagoons, which are more than three metres deep, can provide long-term storage and treatment for six months to one year. Many lagoons in small communities are emptied once per year. Rural communities often make use of surrounding land to dispose of wastewater. When the soil is adequate and there are no water sources nearby, the bacteria in the soil can remove and break down the contaminants in wastewater.[9] Due to the availability of land in many rural areas, this can be an effective method to treat wastewater. However, there are other communities that dispose of waste in a way that threatens the quality of the lake, river or groundwater source that provides drinking water [10].

The Environmental Protection Agency estimates that between 10 and 20 percent of small community wastewater treatment facilities in the United States are not operating properly; state water quality agencies have identified malfunctioning wastewater treatment systems as the second greatest threat to water quality (after underground storage tanks). When the inadequate wastewater treatments are combined with ineffective drinking water treatment, the result is a serious contamination issue for a great number of rural communities.

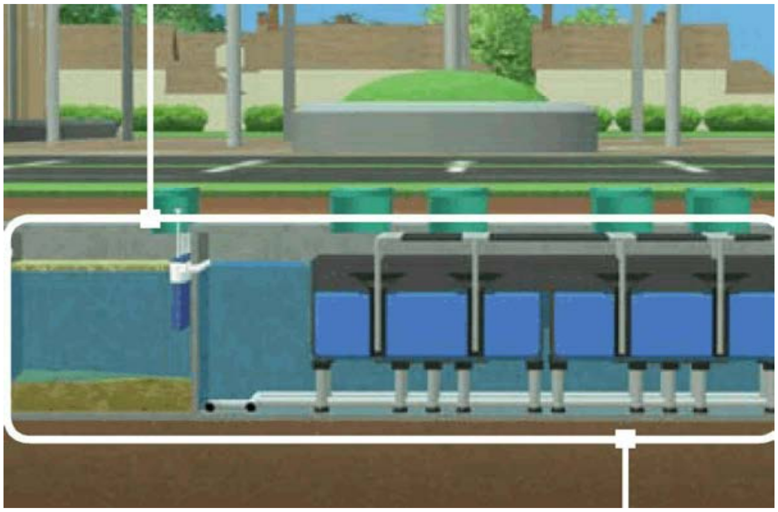

Fig. 3: Wastewater treatment systems are ideal for small communities or commercial properties versus centralized sewering. Simple in design and easy to install, the MyFAST® is a pre-packaged, decentralized treatment system for up to 160,000 gal/day (600 m3/d). Offering versatility of design and flow rates, the MyFAST® maintains consistent high performance, low maintenance and sludge management all in one tank.

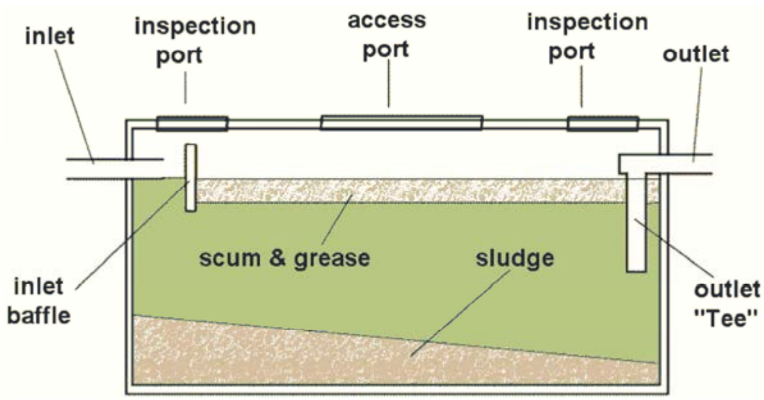

Fig. 4: Washtenaw County, Michigan has graciously provided us with a short video that explains how a septic system works.

Rural communities typically find it difficult to install and maintain wastewater treatment operations. And while many communities have inadequate methods of treating wastewater, there are some communities that are leading the way with innovative methods of treatment and water conservation measures. In several Arctic communities, including Iqaluit, Nunavut, the high cost of water has led to wastewater treatments that allow water to be reused. Wastewater is passed through a septic tank, filtered and disinfected with ozone treatment; it is then reused for non-consumptive uses, such as toilets and laundry. These conservation measures allow them to reuse up to 55 percent of wastewater, while decreasing pressure on wastewater treatment and storage processes [11].

Septic Systems Work: There are many people living in rural areas that are not served by wastewater treatment plants. In fact, according to Environment Canada, as of 2000, only 57 percent of Canadians were served by wastewater treatment plants, compared with 74 percent of Americans, 86.5 percent of Germans and 99 percent of Swedes. Many people in rural areas use septic systems to safely store waste. Wastewater travels through pipes, from the house to a buried septic tank. The diagram below illustrates the basic components of a septic system.

The diagram below illustrates the tank in more detail. In the septic tank, the solids settle to the bottom and a scum forms on the top, similar to the process that occurs in settling tanks in municipal wastewater treatment plants.

Once separated, the water flows out to the drainfield and screens and compartments keep the sludge and scum inside the tank, where bacteria begin to partially digest the sludge. When the partially treated wastewater enters the drainfield, it begins to infiltrate the soil and percolate downwards. So long as the soil is appropriate, the microbes in the soil digest the pollutants, removing the bacteria, viruses and excess nutrients by the time the water reaches the groundwater source [12.]

When the soil is not suitable, or there are nearby water sources, an alternative system may be used, so that water sources do not become contaminated. The alternative system may use sand, peat, or plastic instead of soil. Constructed wetlands, lagoons, aerators, or disinfection devices are also effective in treating the wastewater.

It is estimated that around half of all rural wells are contaminated, many from septic tanks. The United States Centers for Disease Control and Prevention suggests that wells should be at least 15 metres from septic tanks, but this distance also varies according to the type of soil.

In a recent study of groundwater sources in southeastern Michigan by the United States Geological Survey, 38 wells were tested between 1999 and 2001. Of the wells that were near sewerlines, viruses were detected in only two of the 18 wells. Of the 20 wells that were near septic systems, viruses were found in seven wells. This suggests that septic systems are a major cause of groundwater contamination. Previous studies of contaminated wells that were cited by the USGS study found coliforms in up to 80 percent of the wells, as well as some with significant numbers of the E. coli bacterium.

If you are using a septic system, it is important to maintain it properly, as failure to do so could result in the leakage of pollutants into the soil or water sources. The United States Environmental Protection Agency (EPA) recommends that you have your septic system inspected at least once every three years, so that it can be checked for leaks and malfunctions and also be pumped out when it gets full (typically once every three to five years).

- Do not use your drain or toilet as a garbage disposal; avoid putting dental floss, diapers, coffee grounds and paper towel down the drain, as they can clog up your septic system.
- Spread your loads of laundry out over the week. When too much water is added to the septic tank, it does not have time to treat wastes and you could be flooding your drainfield with wastewater.
- Plant grass on your drainfield, but keep trees and shrubs away from it, because roots can clog the system and cause damage.
- Do not drive on your drainfield, because this can compact the soil and damage the septic system components.

Ways to Treat Wastewater: If nature itself can cleanse water, then imitating nature's processes may be the most effective and sustainable ways of treating wastewater. A great deal of water renewal occurs naturally in wetlands. Constructed wetlands consist of a lined cell, which the water flows into. Plants are planted in the cell and the roots filter the contaminants out of the water. Below is a diagram of a constructed wetland. Notice that many of the processes in a wetland are similar to the Biological Nutrient Removal process that was described above.

Another natural method is called rapid infiltration, which is a process where a basin is filled with wastewater, which has already gone through a pre-treatment. The ground acts as a filter and removes the pollutants from the water. This method is similar to what happens in a septic system. A third "natural" process is overland flow, which is used in regions of nearly impermeable ground. The water flows down a sloped surface that is planted with thick grasses. Because the soil is highly impermeable, the water is forced through the vegetation, which effectively removes the pollutants [13].

Slow rate irrigation is a process that uses a portion of land and allows the water to flow slowly enough that the land's capacity to infiltrate the water and remove the impurities is not overburdened. Silviculture is similar to slow rate irrigation, in that it uses a large amount of land to treat wastewater, by planting crops or trees that will flourish during the treatment process. Aquiculture uses aquatic plant and animal species to treat wastewater, similar to the constructed wetland process.

There are also alternative separation systems that can conserve water. One such system separates blackwater (from toilets) from greywater (from showers and dishwashers), so that greywater can be minimally treated and used for watering the lawn. As well, there are incinerating, chemical, or composting toilets that release the waste when it is safe.

Wastewater Pollute Drinking Water Sources: There are a number of ways in which wastewater can cause pollution problems. First of all, not all waste makes it to

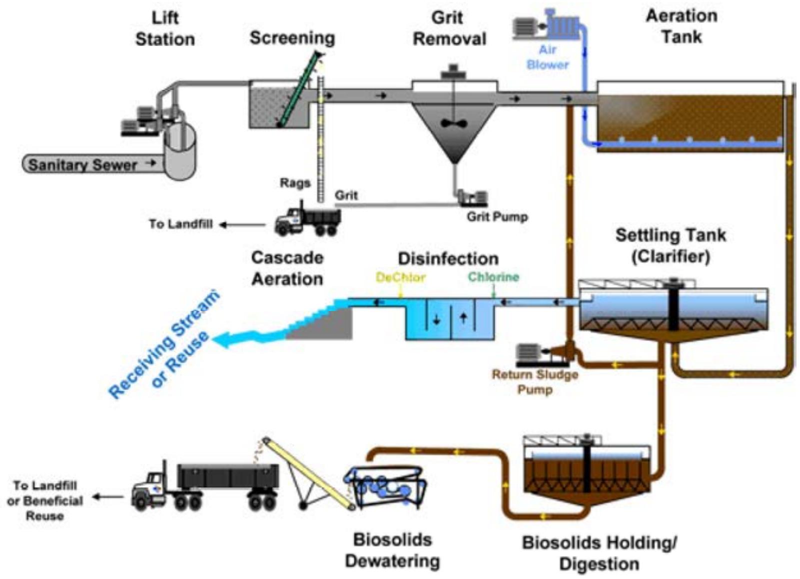

Fig. 5: Exact methods can vary, here's a general breakdown of the municipal wastewater treatment process

the wastewater treatment plant. A study by Sierra Legal found that more than 90 billion litres of untreated sewage were dumped into the Great Lakes each year. That's the same as dumping over 100 Olympic swimming pools of raw sewage into the Great Lakes, every day! Hundreds of billions of untreated sewage are dumped into Canadian waters each year. This graph shows the level of municipal wastewater treatment in Canada, based upon the people who are served by municipal sewer systems. Though the percentage of people who received either no treatment or only primary treatment is decreasing, 24 percent of Canadians are not served by wastewater treatment facilities that are able to remove the majority of harmful substances [14].

Another way in which wastewater can pollute lakes and streams is through municipal sewer failure. Many cities, particularly older ones, have combined sewer systems, which collect domestic sewage in the same pipes as stormwater runoff. During heavy precipitation, the street gutters collect more water than the system can hold. When this happens, a combination of raw sewage and stormwater is released directly into the environment. This is called a combined sewer overflow (CSO). In 2001, Vancouver alone released around 22 billion litres of untreated wastewater into the environment through CSOs. Non-accidental releases, or bypasses, can also occur during maintenance and power failures. In 2001, Ontario reported 144 significant sewage treatment plant bypasses.

Some cities choose to dump raw sewage into the oceans and rivers, because it is cheaper than effective treatment. A report published by Sierra Legal found that, of 22 Canadian cities, Victoria, Dawson City, Montreal, Saint John, Halifax and St. John's dump some or all of their raw sewage directly into water bodies. While not all of the sewage is dumped directly into the oceans, these six cities produce 400 million litres of raw sewage each day! Montreal dumps around 3.6 billion litres of raw sewage into the St. Lawrence River each year and Victoria is the only large Canadian city to dump all of its waste into the ocean without any attempt to improve the system. The city of Victoria dumps more than 34 billion litres of raw sewage into waterways each year and still claims that their actions are not harming the environment! Halifax and St. John's have plans to construct wastewater treatment facilities, but in the meantime, are still discharging 65.7 billion litres and 33 billion litres, respectively, of raw sewage into the Atlantic Ocean.

Public Wastewater Treatment Plants Really Remove All of Those Toxic Chemicals: Commercial and industrial waste is not sent directly to public wastewater treatment plants, because the public wastewater treatment system cannot effectively remove all of the contaminants. Wastewater from commercial and industrial processes is usually divided into the following four categories and dealt with accordingly:

- Some wastewater can be treated on-site and reused within the plant for various purposes.
- There are some wastewater treatment plants that are designed to treat industrial wastewater.

- Some wastewater is similar to domestic wastewater and can be sent to the public wastewater treatment plant. Or, the water may be pre-treated and sent to the public wastewater treatment plant.
- Wastewater from certain processes is very toxic and must be either treated on-site, or disposed of as hazardous waste.

There are more than 23,000 different chemicals and substances that are used in consumer goods and industrial processes in Canada and more continue to be developed. Some of these substances are difficult to remove and can cause significant pollution problems [15].

The Safe Drinking Water Foundation has educational programs that can supplement the information found in this fact sheet. Operation Water Drop looks at the chemical contaminants that are found in water; it is designed for a science class. Operation Water Flow looks at how water is used, where it comes from and how much it costs; it has lessons that are designed for Social Studies, Math, Biology, Chemistry and Science classes. Operation Water Spirit presents a First Nations perspective of water and the surrounding issues; it is designed for Native Studies or Social Studies classes. Operation Water Health looks at common health issues surrounding drinking water in Canada and around the world and is designed for a Health, Science and Social Studies collaboration. Operation Water Pollution focuses on how water pollution occurs and how it is cleaned up and has been designed for a Science and Social Studies collaboration [16.17].

CONCLUSION

River water represents a readily available source of waterfor human activities and historically many civilizations haverelied on the ample supplies of fresh water found in majorriver catchment. Currently, rivers worldwide serve as therecipient of great quantities of waste discharge by agricultural,industrial and domestic activities. The availabilityof fresh water in rivers is one of the major issues facing thehuman population especially in developing countries. The constant discharge of domestic and industrial wastewaterand seasonal surface run-off due to the climate change allhave a strong effect on the river discharge and water quality. Information on water quality and pollution sources isimportant for the implementation of sustainable waterresource management strategies. Physical and chemicalcharacterization of aquatic environment has become an important aspect due to the seasonality of river water. High concentrations of all kinds of pollutants have aninfluence on the river water quality and determine the useof water and also can lead to diverse problems such asalgal blooms, loss of oxygen and loss of biodiversity. It is, therefore, necessary to monitor river water quality,understand the chemistry of the water and provide a reliableassessment of water quality for effective water resourcemanagement.

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