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Assessment of Treatability Studies on Wastewater using Arka Amar, Arka Ayush, Arka Kesar, Arka Naveen Plants and Soil

Bhavan Kumar, K. Venkatesha Raju*, Jagdish H. Godihal, B. P. Janavi and Vaishnavi N. Raj

Presidency University, Department of Civil Engineering, Bengaluru – 560064, Karnataka, India; Venkatesharaju.k@presidencyuniversity.in

Abstract

The objective of the present study was to evaluate the effectiveness of a natural biological treatment unit. Red soil was used as structural support to the plants materials of four different Arka varieties in the treatment unit. The study also sought to ascertain the efficiency of the treatment facility in lowering various contaminants such as heavy metals- chromium, nickel, zinc, and nutrients like nitrate and phosphate as well as Total Suspended Solids (TSS), Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand COD etc. Analytical results of the study demonstrated that the wastewater treatment was highly perceptible with an average efficiency of 98% for COD and 96.5% for BOD, displaying the ability of natural materials to break down organic matter in the wastewater. TSS was significantly reduced by the treatment as well, with an efficiency of 75%, while TDS and TS were showed less than 50% efficiency. In addition, 67% and 60% efficiency was observed for nitrates and phosphates respectively that are known to contribute eutrophication in aquatic ecosystem. Apart from this biological treatment unit was successful in lowering chromium metal concentration with an efficiency of up to 90%. The obtained result findings of our study, plainly signposted that the natural biological treatment of wastewater is a workable and sustainable alternative to conventional treatment. The natural biological treatment could be ideal for sparsely populated rural areas with limited access to conventional wastewater treatment facilities..

Keywords: *Arka Plants, Biological Treatment, Metals, Nutrients, Wastewater*

1.0 Introduction

1.1 Sewage Water

Before being released into other bodies of water, wastewater, which is used water containing pollutants, must be treated. To stop further contaminating our water supplies, this is important. There are many different sources of wastewater, including runoff, agriculture, and industrial processes. Nonetheless, treating industrial wastewater can be more difficult than treating home wastewater[1].

In order to make our rivers and streams safe for a variety of uses, including swimming, fishing, and drinking water, wastewater treatment is essential. In the past, low dissolved oxygen levels, fish mortality, algal blooms, and bacterial contamination were frequently experienced in urban streams due to pollution. At first attempt to reduce pollution centered on minimizing floating debris and preventing human waste from getting into water sources. The panorama of pollution has changed as a result of population development and industrialization, which have increased demands on our natural resources[2].

**Author for correspondence*

Eutrophication of receiving waters has intensified due to increased wastewater production and discharge, which is detrimental to aquatic life[3]. As a result, before to disposal, wastewater must be cleaned of organic debris, nitrogen, and phosphorus. This is required to lessen the damaging effects that wastewater discharge has on our water resources. Many streams continue to be impacted by various pollutants, making it difficult for them to be used for a variety of purposes, despite a substantial investment in water pollution treatment. We must update previous methods for preventing water contamination and adjust to new problems in order to meet these worries.

1.2 Types of Wastewaters

Domestic and industrial wastewater are the two main categories of wastewater[4]. Domestic wastewater is largely produced by households, although it can also contain groundwater runoff and water discharged from commercial and institutional structures. It is a murky, hazy liquid with suspended particulates that smells musty. Domestic wastewater contains a variety of pathogens and germs, as well as the elements carbon, nitrogen, phosphorus, sulfur, hydrogen, lipids, carbohydrates, enzymes, and proteins. Also, it could include floating debris like faeces, food scraps, oil, waste, paper, rags, wood, plastic, and other things that are frequently discarded in a neighborhood[5].

The most significant benefit of treating domestic wastewater is that it helps to stop the spread of disease. Many harmful species, such as bacteria, viruses, protozoa, and helminth eggs, can cause infections in untreated wastewater. These pathogens can spread via a number of different pathways, including hand-to-mouth, clothing-to-mouth, and food-to-mouth contact, soil-based transmission through excreted organisms in the soil, insect-vector transmission via insects that feed or breed in water (such as flies and mosquitoes), and water-borne transmission via contaminated water supplies[6]. In order to stop the development of these diseases and safeguard public health, proper wastewater treatment is essential.

Due to its varying content, flow, and volume, industrial wastewater, which is produced during numerous manufacturing operations, might be harder to treat than household wastewater. The community's industry or manufacturing facility, as well as the use to which the water has been put, determine the precise type and volume of industrial wastewater.

Many businesses, including paper and fiber facilities, steel mills, petrochemical and refining activities, chemical and fertiliser plants, meatpacking and poultry processing plants, vegetable and fruit packing operations, and many more, produce large amounts of wastewater. Industrial wastewater may contain toxic compounds that impair sewage systems and other infrastructure or strong organic matter with a high oxygen demand. Certain substances might not degrade biologically or might include harmful elements that disrupt the operation of wastewater treatment facilities. The electric power industry is the major user of cooling water, but primary metal and chemical industries also use a significant amount of it in their operations.

An important step in the process of removing solids from wastewater is wastewater treatment, which also partially decomposes complex, highly putrescible organic solids into mineral or reasonably stable organic solids. Because of the decomposition of the organic components it contains, accumulated untreated wastewater can result in the generation of significant amounts of foul-smelling fumes. Moreover, it frequently includes a large number of potentially harmful pathogenic germs as well as other poisonous substances. Untreated wastewater poses a risk to both human and environmental health by encouraging the growth of aquatic vegetation. In order to avoid annoyances and to advance public and environmental health, it is crucial in modern civilization to remove, treat, and dispose of wastewater at the source of generation.

The need for the removal of nitrogen, phosphorus, and organic matter from wastewater before disposal has increased in response to the growing need to reduce the negative consequences of wastewater discharge. Traditional treatment approaches can successfully accomplish this goal, but they frequently have large operational costs and energy requirements. For small to medium-sized settlements, sparsely inhabited areas, and poor nations in particular, it might be feasible to dispose of wastewater into natural biological treatment systems.

1.3 Treatability Studies

In a treatability study, hazardous waste is put through various physical, chemical, biological, or thermal procedures to see if it can be treated. The effectiveness of the treatment procedure for a particular waste is evaluated, along with the necessity of pretreatment, ideal treatment conditions, and residual volumes and characteristics from various treatment processes. Assessing material compatibility, including corrosion and linear compatibility, as well as carrying out toxicological and health effect studies are also included in the definition of a treatability research. It is crucial to understand that treatability studies cannot be used to hazardous waste treatment or disposal in the private sector[7]. Furthermore, neither the land placement of hazardous waste nor the open burning of such garbage may be used in these investigations.

1.4 Wetlands

Wetlands are distinct ecosystems that may experience seasonal or persistent flooding, which causes the soil to become anoxic. Wetlands differ from other types of land or water bodies due to the existence of aquatic plants that have evolved to survive in this environment. They are renowned for their extraordinary biological diversity, which serves as habitat for several plant and animal species. Wetland functions, ecological health, and general state may all be evaluated using a variety of techniques, which has helped to increase public awareness and support global conservation efforts.

Except for Antarctica, all continents have some form of wetland that can hold fresh, brackish, or saltwater. According to the predominant plant species or the supply of water, they are categorized. For instance, emergent plants like reeds, cattails, and sedges are typical of marshes, but woody plants like trees and shrubs predominate in swamps. Depending on where the water comes from, wetlands can also be categorised as tidal wetlands, estuaries, floodplains, springs, seeps, fens, bogs, or vernal ponds. Some wetlands are difficult to classify since they contain a variety of plant species and get their water from various sources.

1.5 Physico-Chemical and Heavy Metals

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The evaluation of various physical and chemical properties of water is a part of physico-chemical analysis.

- If groundwater is contaminated with contaminants like sewage, we can tell by examining the physico-chemical parameters of its quality. This examination indicates the suitability of groundwater for various uses, such as drinking, bathing, and cleaning utensils. It also helps determine whether polluted water has filtered into the groundwater.
- Physical-chemical analyses take into account variables including turbidity, pH, alkalinity, electrical conductivity, total solids, total dissolved solids, dissolved oxygen, sulphate, nitrate, total hardness, and suspended solids.
- The main source of dangerous heavy metals like lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As) for human health is industrial activity. These metals gradually accumulate in the nearby soil and water. Heavy metal concentrations indoors are often lower than that outdoors.

Heavy metals have a number of characteristics, such as being found near the bottom of the periodic table, having high densities, being toxic, and not degrading[10]. The main objectives of the study are designing and developing a treatment plant for wastewater and evaluating the potential accumulation of metals and nutrients in ornamental plants.

2.0 Methodology

2.1 Sewage Water for Treatability Study

Sewage influent has been procured from BWSSB treatment plant, Hebbal, Bangalore, which is located with the GPS coordinates of 13°02'37.5"N 77°36'12.3"E.

2.2 Procurement of Materials for Treatability Study

In setting of treatability unit in the laboratory material required are listed and procured from locally available construction site, plant nursery and market.

2.2.1 Boulders

Boulders were collected from the Presidency university construction site and checked for required size in the Geotechnology laboratory. The natural biological treatment unit's bottom was filled with a 5 cm size boulder, and the spaces were filled with smaller pebbles, which helps to prevent soil from passing through it and clogging the pipe (Figure 1).

Figure 1. Boulders.

2.2.2 Red Soil

The required amount of around 200 kg of red soil was obtained from plant nursey. Effective treatment necessitates sufficient contact time with microorganisms, which must be provided by at least three feet of aerated or unsaturated soil. The effluent can flow across the surface area provided by soil particles, which filters out bigger contaminants and immobilizes pollutants by chemically bonding with minerals. Anaerobic bacteria perform efficiently in saturated soil with no oxygen available, aerobic bacteria offer the best treatment in aerated soil (Figure 2).

Figure 2. Red soil.

After cleaning small gravels and other debris soil was delivered to the lab. To provide enough treatment and filtration for safe treatment of effluent BOD, a three-foot separation distance is needed between the bottom of the dispersal media and a limiting soil condition, such as groundwater or bedrock.

2.2.3 Pipes

Transparent plastic pipes of diameter 5 mm was used to pass the influent to treatment unit and treated one to effluent collection tank. To ensure that suspended particles settle at the bottom of the primary settling tank, pipe is installed at the free board of 5 cm (Figure 3).

Figure 3. Pipe.

2.2.4 Valves

There are valves available to control the discharge flow at rates of 10ml/min and 20ml/min (Figure 4).

Figure 4. Valves.

2.2.5 Plastic Water Dispenser

The 50-litre plastic water dispenser is translucent in colour, 32 cm in diameter and 38 cm in height. The biological treatment unit uses it (Figure 5).

Figure 5. Plastic water dispenser.

2.2.6 Bisleri Can

These cans can have used is of transparent color of volume 20Litres. It is used for Influent and Effluent tank (Figure 6).

Figure 6. Bisleri can.

2.3 Plant Material Procurement

Four different Arka verities of ornamental plant viz., Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar were procured from the Indian Institute of Horticulture Research (IIHR), The plant science department at IIHR was contacted to select ornamental plants based on their growth stages, lifetime, and adaptability. The vegetative tubers were preferred than seeds, since they grow more swiftly and mature more quickly.

2.3.1 Arka Amar

It is also known as Gladiolus, is a hybrid variety, developed through selective breeding. It is a cross between the watermelon Pink and Aarti varieties and has a relatively short blooming period of 72 days. The plant produces long spikes that can grow up to 101cm in length with a good rachis length of 50cm. Each spike bears a total of 17 florets. Arka Amar is capable of yielding 1.81 flower spikes per corm, and each spike contains an average of 16.6 florets (Figure 7).

Figure 7. Arka Amar.

2.3.2 Arka Aayush

This variety is developed through the process of hybridization and selection. It has a fast blooming time of 77 days and produces long spikes that reach a length of 95.18 cm. The rachis length is also noteworthy, measuring 48.81 cm. Each corm produces an average of 1.7 spikes.

Figure 8. Arka Ayush.

The flowers are visually striking, with red petals and a yellow border. The blooms are open faced, thick, slightly ruffled, and arranged in double rows. This variety has been observed to be resistant to fusarium wilt disease (Figure 8).

2.3.3 Arka Kesar

It is developed by crossing Vink's Glory with Sagar. This variety produces stunning saffron-colored flowers and has a spike length of 111 cm. It typically blooms within 61 days. Additionally, it boasts moderate resistance to Fusarium wilt disease (Figure 9).

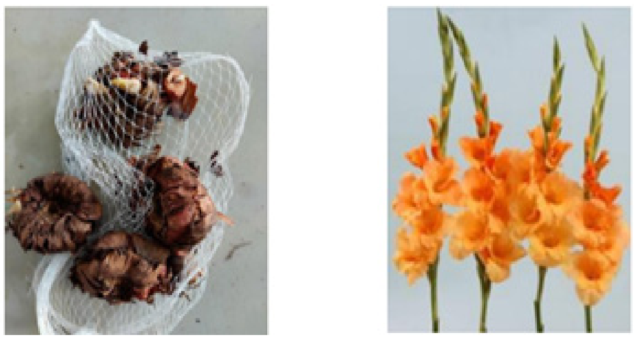


Figure 9. Arka Kesar.

2.3.4 Arka Naveen

This variety is developed through hybridization and selection from Hybrid 74-39-1 and Tropic Sea. It has a short blooming period of only 66 days and boasts an impressive spike length of 111 cm. The rachis length is also good at 55 cm, and each spike produces 16 florets that are purple with a pale yellow blotch and wavy tepals. In terms of yield, Arka Naveen (Gladiolus) produces an average of 27.68 spikes per square meter per crop season (Figure 10).

Figure 10. Arka Naveen.

2.4 Treatability Steps

1. Install four pilot plants.
2. Gather and prepare boulders and soil.
3. Analyze the natural state of the soil.
4. Establish the pilot treatment unit.
5. Fill tanks with boulders and soil.
6. Wash soil with distilled water.
7. Collect seeds and vegetative tubers.
8. Plant ornamental vegetative tubers.
9. Watering of plants with wastewater till maturity.
10. Collect untreated sewage from Hebbal STP.
11. Analyze the untreated sewage influent.
12. Treat the influent sewage at a discharge rate of 20ml/min using four treatment plants.
13. Analyze the effluent.
14. Analyze the potency of plants and soil.

Figure 11. Setup of pilot plant.

2.5 Setting up of Pilot Plant

At the Environmental Lab, Civil Department in Presidency University, four separate pilot plants were established and cultivated ornamental plants using wastewater (Figure 11). The pilot plants were named as below

Plant 1: Arka Amar plant
Plant 2: Arka Ayush plant
Plant 3: Arka Kesar plant
Plant 4: Arka Naveen plant

There are three units make up each plant:

a) Primary settling tank

b) A unit for natural biological treatment

c) A wastewater collection tank

During primary treatment, wastewater is directed to a settling tank where it is held for approximately one hour to allow various types of suspended particles to settle. To prevent clogging of pipes in the treatment plant, a freeboard of 5cm is maintained for these suspended materials. As a result of this settling process, the concentration of suspended solids in the wastewater is reduced, thereby reducing its strength.

In the natural biological treatment unit, large boulders measuring 40 meters are used and placed at a depth of 4cm. Smaller pebbles are then used to fill in the gaps between the boulders. A layer of red soil, which can pass through a 6.3mm sieve, is then placed on top of the pebbles for a depth of approximately 31.5cm. This treatment unit relies on the action of microbes present in the soil to treat the wastewater. Additionally, the plant roots in the unit absorb both the organic and inorganic nutrients present in the wastewater. Through these processes, all nitrates, phosphates, BOD, COD, and other contaminants are removed from the wastewater. The last unit that is the effluent collecting tank is for the purpose of storing the effluent.

3.0 Results and Discussion

3.1 pH

According to the graph, there was an increase in pH values after treatment with different variants of Arka at a discharge rate of 20 ml/min. The influent pH was 6.8, which increased to 7.05, 7.45, 7.36, and 7.08 after treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar, respectively.

3.2 Total Dissolved Solids

It is found that there is a decrease in Total dissolved solids. For influent T.D.S value is 850mg/l which has been decreased to 424, 740, 474, and 586mg/l by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively at discharge rate of 20ml/min. Efficiency of TDS is reduced to 50.1%, 12.94%, 44.23%, and 31.05% by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively when wastewater is treated at a discharge rate of 20ml/min.

3.3 Total Solids

As depicted in the graph TS value is 882mg/ in influent, has been decreased to 424,740,476, and 589mg/l by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively at discharge rate of 20ml/min. Efficiency for Total solids is reduced to 51.92%, 16.1%, 46.03%, and 33.2% by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively at a discharge rate of 20ml/min.

3.4 Sodium

From the graph, it was exhibited that there is a decrease in Sodium. In influent Sodium value is 60mg/l and has been decreased to 20,30, 32, and 35mg/l by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively at discharge rate of 20ml/min. Efficiency of Sodium is decreased to 66.67%, 50%, 46.67%, & 41.67% by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively at a discharge rate of 20ml/min.

3.5 Total Alkalinity

It was found that there is a decrease in Total alkalinity. Total alkalinity is 408mg/l in influent has been decreased to 51.4,115, 67.3, and 67.3mg/l with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively at discharge rate of 20ml/min. Efficiency of Total alkalinity is reduced to 87.4%, 71.8%, 83.5%, and 83.5% by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively at a discharge rate of 20ml/min.

3.6 Chloride

As graph showed chloride content (112.5mg/l) was decreased to 88, 97.8,103 and 98mg/l in Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar plant treatment unit respectively at discharge rate of 20ml/min. Efficiency of Chloride is reduced to 21.18%, 13.07%, 8.44%, and 12.89% by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively.

3.7 Sulphate

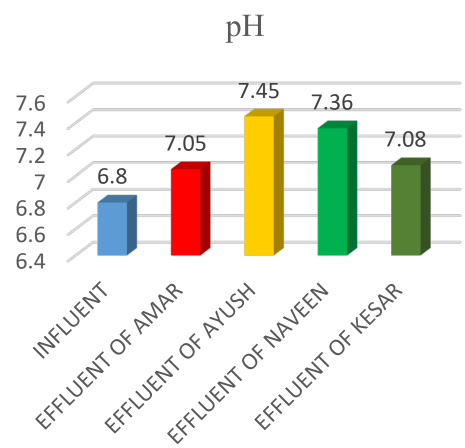
Sulfate was found that there is a decrease in Sulphate. For influent Sulphate recorded 40.5mg/l, which has been decreased to 30.3, 30, 29.7, and 32.4mg/l by treatment with Arka Amar, Arka Ayush, Arka Naveen, Arka Kesar respectively at discharge rate of 20ml/min. Efficiency of Sulphate is reduced to 25.18%, 26.67%, 20%, by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively when wastewater is treated at a discharge rate of 20ml/min.

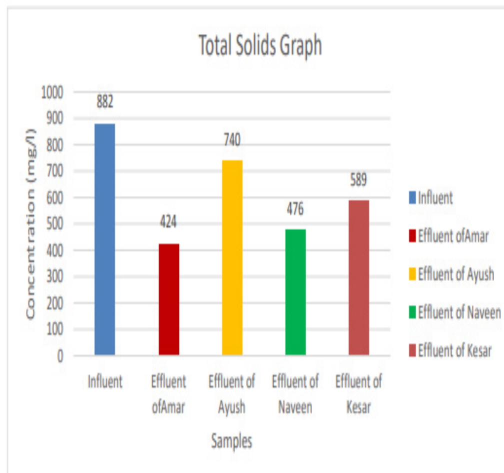
3.8 Nitrate

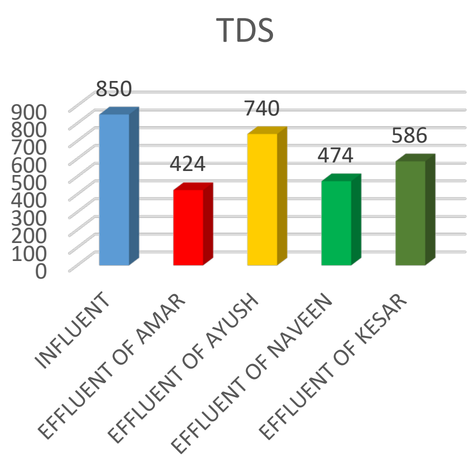
It was found that there is a decrease in Nitrate. For influent Nitrate value is 48mg/l which has been decreased to 18,17,15.8, and 16mg/l and efficiency of Nitrate is reduced to 62.5%, 64.58%, 67.08%, and 66.67% by treatment with Arka Amar, Arka Ayush, Arka Naveen, & Arka Kesar respectively at discharge rate of 20ml/min.

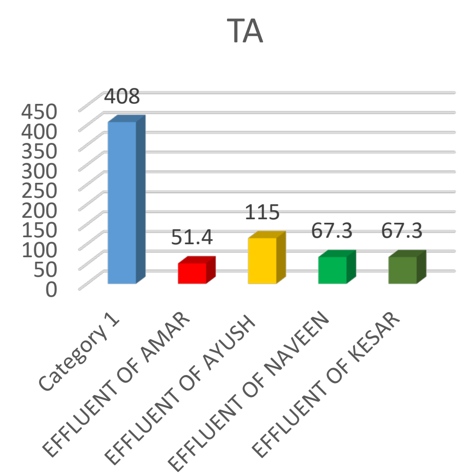
3.9 Phosphate

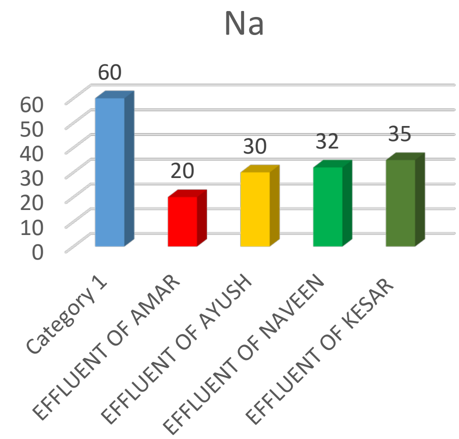
From the graph, we found that there is a decrease in Phosphate. For influent Phosphate value is 0.1mg/l which has been decreased to 0.04, 0.04, 0.04 and 0.04mg/l by treatment with Arka Amar, Arka Naveen, Arka Kesar respectively at discharge rate of 20ml/min. Efficiency of Phosphate is reduced to 60%, 60%, 60% and 60% by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively when wastewater is treated at a discharge rate of 20ml/min.







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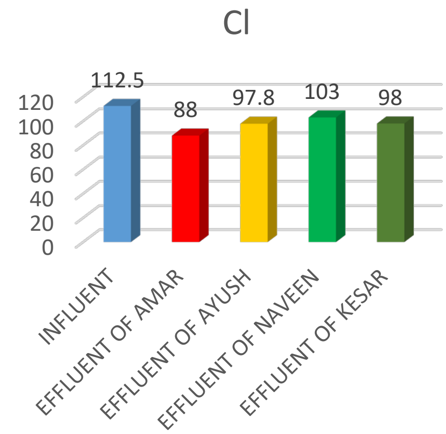
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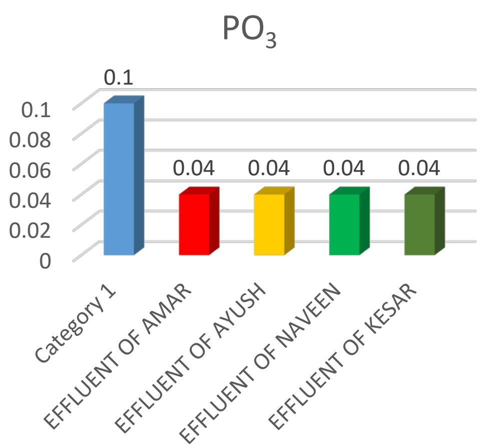
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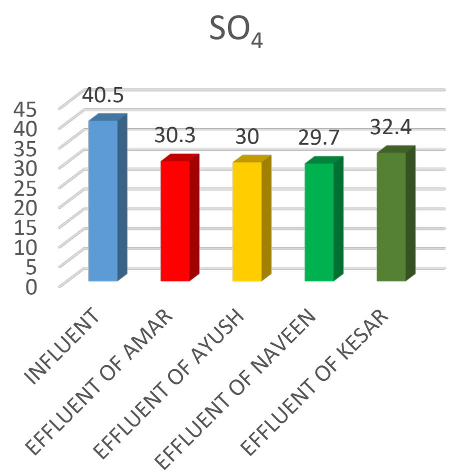
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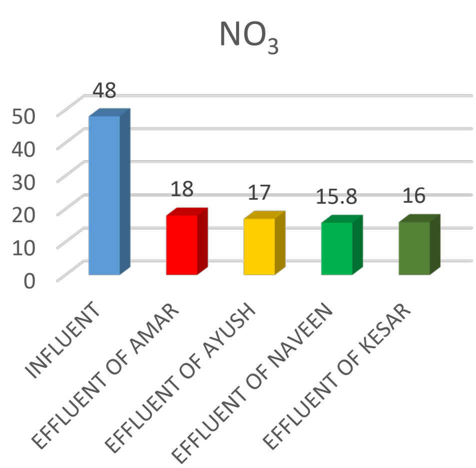
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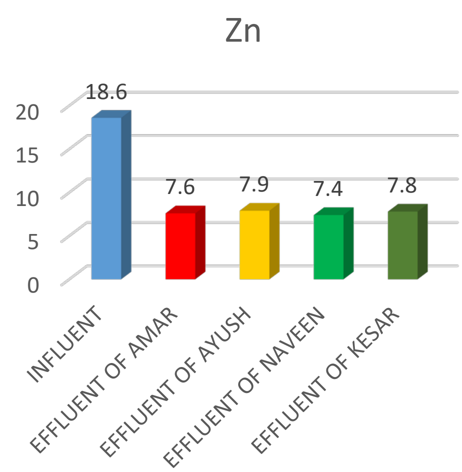
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Figure 2. Bar graphs showing physicochemical and metal concentrations in influent and effluents.

3.10 Total Chromium

According to the graph, the treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar at a discharge rate of 20ml/min has resulted in a reduction of Total Chromium from 0.11mg/l to 0.03mg/l, 0.02mg/l, 0.01mg/l, and 0.02mg/l, respectively. This means that each of these treatments has successfully reduced the concentration of Total Chromium in the influent water. When treating wastewater at a discharge rate of 20ml/min, the efficiency of Chromium reduction is decreased to 72.7%, 81.8%, 90.9%, and 81.8% after treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar, respectively.

3.11 Nickel

Based on results showed in graph, it was observed that the concentration of Nickel has been reduced during the treatment process. The initial concentration of Nickel in the influent was 0.03 mg/l.

However, after treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar at a discharge rate of 20 ml/min, the concentration of Nickel decreased to 0.02 mg/l, 0.015 mg/l, 0.011 mg/l, and 0.01 mg/l, respectively.

Further, the efficiency of the treatment process in removing Nickel from wastewater was determined. At a discharge rate of 20 ml/min, the efficiency of Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar in removing Nickel was 33.33%, 50%, 63.33%, and 66.67%, respectively.

3.12 Zinc

It was found that there is a decrease in Zinc. For influent Zinc value is 18.6mg/l which has been decreased to 7.6,7.9, 7.4, and 7.8mg/l by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar at discharge rate of 20ml/min. Efficiency of Total solids is reduced to 59.13%, 57.52%, 60.2%, and 58.06% by treatment with Arka Amar, Arka Ayush, Arka Naveen, and Arka Kesar respectively when wastewater is treated at a discharge rate of 20ml/m.

3.13 BOD

There is a reduction in BOD level from 220mg/l to 7.4, 7.45, 7.2 and 6.9 mg/l. Arka Kesar provided maximum reduction of BOD of 97%.

3.14 COD

It was observed maximum removal of COD by Arka kesar plant (6.1mg/l). While minimum noticed in Arka ayusha (10.2mg/l).

4. Conclusion

The Biological treatment method of this study concluded that plants which are taken for removal of nutrients and metals has achieved the desired results. The treatment method using plants and soil is a viable alternative for conventional treatment especially for sparsely populated areas.

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