Journal of Mines, Metals and Fuels, *71(10): 1785-1792; 2023. DOI: 10.18311/jmmf/2023/35876*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.com/index.php/jmmf*

Evaluation of Accumulation Potency of Arka Plant Varieties for Metals and Nutrients through Natural Biological Treatment

Bhavan Kumar*, K. Venkatesha Raju and Jagdish H. Godihal

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

Abstract

This study aims to evaluate the effectiveness of a natural biological treatment system for wastewater using Red soil, Arka Darshan, Arka Tilak, Arka Nirantara, and Arka Prajwal plants. The system employs clay as a natural nanomaterial for adsorption of substances such as nitrates, phosphates, potassium, and heavy metals. The soil contains numerous microorganisms that decompose organic matter into simpler compounds, while the plants use phytoremediation to uptake heavy metals and nutrients. The study measured the system's efficiency in reducing Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Phosphate, Magnesium, Zinc, Nitrate, Sodium, and Potassium. The results showed that the system had an average efficiency of 98% in COD and 96% in BOD removal, and contributed an efficiency of 99% TSS and 46% TDS. The system also removed nitrates and phosphates, which cause eutrophication in water bodies, by 76% and 72%, respectively. Additionally, heavy metals like chromium, Nickel and Zinc were reduced by up to 81%, 71% and 59%. The study suggests that the natural biological treatment system is a sustainable and effective alternative to conventional wastewater treatment, particularly in sparsely populated rural areas. Therefore, we can conclude that this system has potential for wider adoption in treating wastewater.

Keywords: *Arka Plants, Biological Treatment, Metals, Nutrients, Red Soil etc.*

1.0 Introduction

The treatment of wastewater is crucial before it is released into water bodies to prevent further pollution of our water sources. Wastewater can come from different sources such as agricultural and industrial processes, as well as runoff. However, industrial wastewater is often more challenging to treat than household wastewater.

To ensure that our rivers and streams are safe for various activities like swimming, fishing, and even drinking, it is imperative to treat wastewater. In the past, pollution in urban streams resulted in low dissolved oxygen levels, fish mortality, algal blooms, and bacterial contamination. Initially, measures were put in place to prevent human waste and floating debris from getting into water sources. However, the increasing demand for natural resources due to population growth and industrialization has led to changes in the pollution landscape.

The discharge of wastewater has intensified eutrophication in receiving waters, which is harmful to aquatic life. Therefore, wastewater needs to be rid of organic debris, nitrogen, and phosphorus before disposal to minimize its adverse effects on our water sources. Despite significant investments in water pollution treatment, many streams remain affected by various pollutants, making it challenging to use them for different purposes. As a result, we need to update our previous pollution prevention methods and adapt to new challenges to tackle these concerns effectively.

*Author for correspondence

To determine whether hazardous waste can be treated, a treatability study is conducted using physical, chemical, biological, or thermal processes. This study evaluates the effectiveness of the treatment method for a specific waste and determines the need for pretreatment, ideal treatment conditions, and residual volumes and properties from various treatment processes.

Environmental Impact Assessment of Anthropogenic Activities and Conceptual Restoration Strategy for Kham River in Aurangabad, India. In this study, the ecological survey was carried out by transect walk through and along the basin of Kham river. In this survey flora and fauna in the basin, flora along the basin, and species of the birds in the vicinity of the basin were observed. The ecological survey states that there are varieties of flora species responsible for improving the water quality[1].

Soil filtration can be used in the treatment of wastewater which undergoes pre sedimentation and can be affected by the pollutant load of the filtration environment[2].

The transgenic plants has improved phytoremediation capabilities and their potential can be used in environmental cleanup[3].

Capability of water hyacinth in removing heavy metals such as Cadmium (Cd), Chromium (Cr), Copper (Cu), Zinc (Zn), Iron (Fe), and Boron (B) in ceramic wastewater was can be concluded as a best plant for phytoremediation process[4].

Wetlands are ecosystems that experience flooding, either seasonally or persistently, leading to anoxic soil conditions. Unlike other types of land or water bodies, wetlands are home to aquatic plants that have adapted to thrive in this environment. The remarkable diversity of plant and animal species in wetlands makes them important habitats for ecological health. Wetlands can be found on all continents except Antarctica and are categorized based on the predominant plant species or the water supply. Marshes, for example, are characterized by emergent plants such as reeds, cattails, and sedges, while swamps are dominated by woody plants like trees and shrubs. Wetlands can also be classified according to their water source, such as tidal wetlands, estuaries, floodplains, springs, seeps, fens, bogs, or vernal ponds. However, some wetlands are difficult to classify as they have a variety of plant species and get water from multiple sources. Various techniques are used to evaluate wetland functions, ecological health, and overall condition, which has helped to raise public awareness and support global conservation efforts.

Physico-chemical analysis involves the evaluation of physical and chemical properties of water. By examining the quality of groundwater's physico-chemical parameters, we can determine if it has been contaminated with pollutants like sewage and assess its suitability for various uses such as drinking, bathing, and cleaning. This type of analysis also aids in determining if polluted water has seeped into the groundwater. Parameters considered in physical-chemical analyses include turbidity, pH, alkalinity, electrical conductivity, total solids, total dissolved solids, dissolved oxygen, sulphate, nitrate, total hardness, and suspended solids. Industrial activities are the primary source of hazardous heavy metals like lead (Pb), mercury (Hg), cadmium (Cd), and arsenic (As) for human health, which gradually accumulate in the surrounding soil and water. Heavy metal concentrations indoors are often lower than those outdoors.

Municipal wastewater is composed of storm water runoff and various types of waste from households, commercial establishments, and industries. The waste is composed of a diverse range of suspended and floating materials such as grit, inert particles, paper, plastics, and other debris. Process water from industrial and commercial operations contain various pollutants such as animal hair, blood, offal, milk fat, hydrocarbons, heavy metals, detergents, dyes, and solvents, which may lead to operational challenges and high nutrient loading. Sewage treatment facilities need to be designed, managed, and operated with these sewage properties in mind. Monitoring incoming sewage can help identify substances that might affect plant efficiency, and pretreatment measures are required to eliminate floating and suspended waste, grit, and other components that may interfere with downstream treatment processes and make disposal difficult. In addition, stricter regulations are required to regulate storm water overflows due to the high organic loading resulting from sources such as milk or blood wastes, to safeguard receiving water bodies.

2.0 Objective of the Study

The core objective of this study embraces assessment and scheming investigational treatment unit to remove nutrient, organic matter and metal contaminants in the sewage water.

3.0 Materials and Methodology

3.1 Sample Collection

Sewage influent has been collected from BWSSB treatment plant, Hebbal, Bangalore. Which is located with the GPS coordinates of 13^{0}02'37.5"N 77^{0}36'12.3"E.

3.2 Selection of Materials for Treatment Unit

3.2.1 Boulders

The boulder size of 5cm was placed at the bottom of the natural biological treatment unit and also smaller size pebbles were used to fill the voids which helps to control soil to pass through it and clog the pipe.

3.2.2 Soil

200 kg of red soil that was obtained from plant nursery. To provide effective removal and filtration organic matter in the effluent, a three-foot separation distance is needed between the bottom of the dispersal media and a limiting soil condition, such as groundwater or bedrock.

3.2.3 Valves

Valves are provided to regulate the flow of discharge *i.e.,* at the rate of 10ml/min and 20ml/min.

3.2.4 Pipes

Pipes are of 5mm in diameter. Pipe is provided at the free board of 5cm for primary settling tank from bottom so that suspended particles settle at the bottom. Pipes used are made of plastic and is of white color.

3.2.5 Plastic Cans, Valves and Pipes

Bisleri can used is of transparent color of volume 20 litres. It is used for Influent & Effluent tank.

3.2.6 Plastic Water Dispenser

Plastic water dispenser used is of transparent color of volume 50 litres. Diameter of 32cm and height of 38cm. It is used for biological treatment unit.

3.3 Selection of Plant Material

Four ornamental plants namely Arka Prajwal, Arka Darshan, Arka Nirantara, and Arka Tilak, which are developed through hybridization and selection, were chosen for the treatability study. We took into account diverse decorative plants' growth stages, lifespans, and adaptability. Vegetative tubers are preferred since they grow and mature swiftly than seeds.

3.3.1 Arka Prajwal (Gladiolus)

This variety of Gladiolus developed from Watermelon Pink Aarti. This plant produces blooms in just 77 days, boasting a long spike of 48.81cm with a good rachis length of 95.18cm, and bears 17 florets per spike. With a yield of 1.7 flower spikes per corm, this is capable of producing 16.6 florets per spike.

3.3.2 Arka Darshan (Gladiolus)

From watermelon pink, Shirley, a Gladiolus variety boasts a medium spike length of 87cm, a nice rachis length of 67cm, and bears 15 florets per spike. It blooms in just 85 days with red-purple flowers that have blotches.

3.3.3 Arka Nirantara (Tuberose)

This Gladiolus variety, blooms in just 77 days. It has a long spike length of 98.18cm with a good rachis length of 48.81cm and can produce 1.7 spikes per corm. The florets are open-faced, thick, slightly ruffled, and arranged in double rows. This variety is resistant to Fusarium wilt disease.

3.3.4 Arka Tilak (Gladiolus)

This Gladiolus cultivar, from Black Jack x Friendship, which blooms in just 60 days. It boasts a 1.04cm spike length and bears an amazing 113 florets per spike.

3.4 Treatability Study

The study involved the establishment of four pilot plants. Collection and preparation of boulders and soil was carried out. Soil analysis was performed in its natural state. Pilot treatment units were established by filling tanks with boulders and soil, and washing them with distilled water. Ornamental plant seeds or vegetative tubers were collected and sowed. The plants were irrigated with wastewater until they reached maturity. Untreated sewage was obtained from Hebbal Sewage Treatment Plant. Analysis of the influent (untreated sewage) was conducted. Four treatment plants were utilized to treat the influent at a 20 ml/min discharge rate. The effluent (treated sewage) was analyzed.

3.5 Setting Up of Pilot Plant

The effectiveness of both the plants and soil was analyzed.

Separate pilot plants were established for each of the four ornamental plants being investigated at the environmental lab of the Civil Department in Presidency University.

Each plant consists of three units namely:

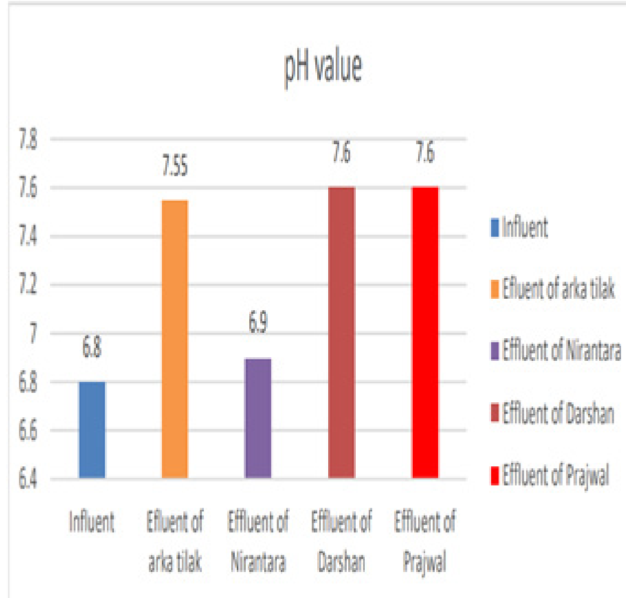
1. Primary settling tank
2. Natural biological treatment unit
3. Effluent collecting tank

Figure 1. Setup of pilot plant.

In the primary settling tank, suspended materials are given time to settle for a period of approximately 30 minutes. To prevent clogging of pipes within the treatment plant, a 5cm free board is maintained for the suspended materials. The settling process effectively reduces the strength of the wastewater (Figure 1).

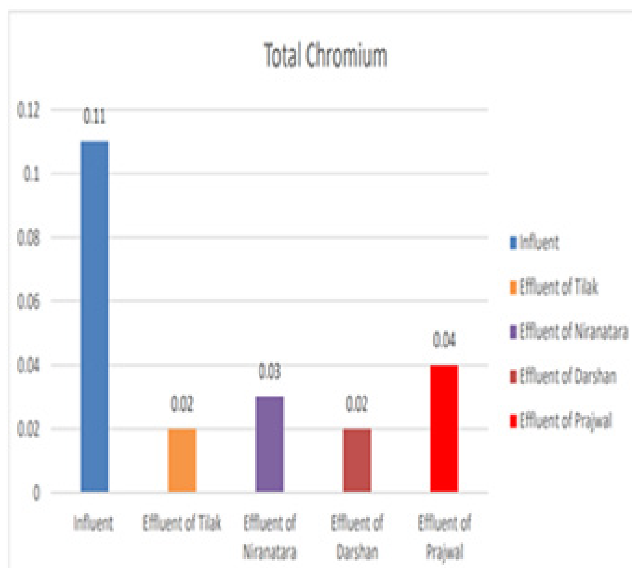
4.0 Results and Discussion

Graphs has been plotted for the obtained results of lab analysis and are compared among plants for individual parameter.

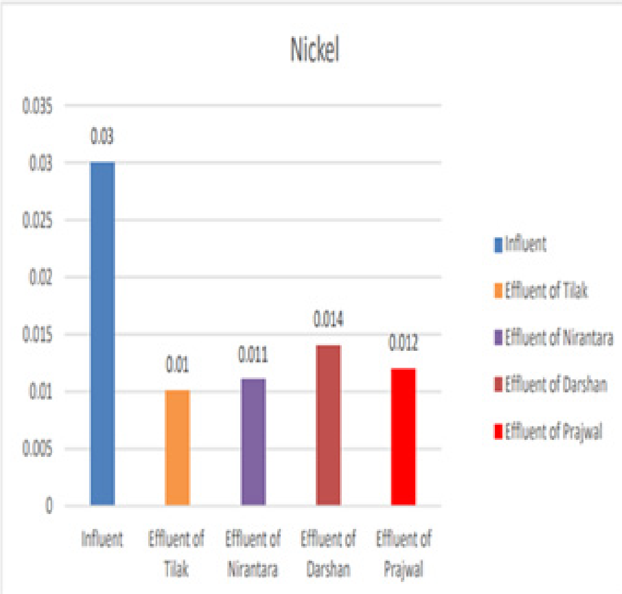


Graph 1. pH graph.

From the above graph 1, it can be observed that there is increase in pH levels after treatment with Arka Tilak, Arka Niranatara, Arka Darshan, and Arka Prajwal, at a discharge rate of 20ml/min. The influent pH value of 6.8 is increased to 7.55, 6.9, 7.6, and 7.6, respectively, for each treatment.

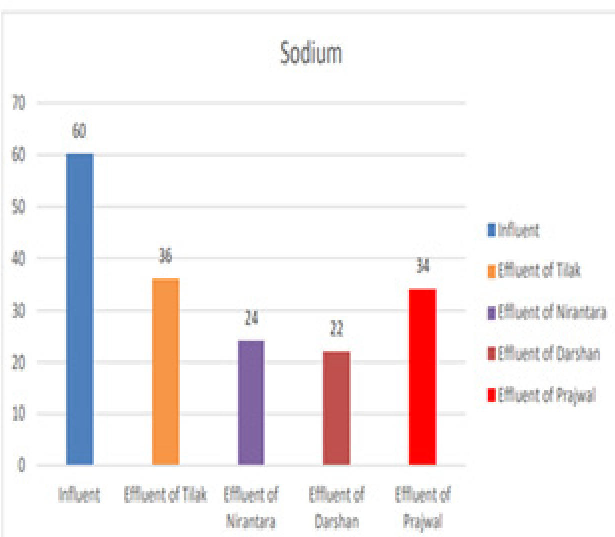


Graph 2. Total chromium.



Graph 3. Nickel graph.

It can be observed in the above graph 2, that there is a significant reduction in Total Chromium levels after treatment with Arka Tilak, Arka Nirantara, Arka Naveen, and Arka Kesar, at a discharge rate of 20ml/min. The influent Total Chromium value of 0.11mg/l has been decreased to 0.02, 0.03, 0.02, and 0.04mg/l, respectively, for each treatment. The efficiency of Chromium removal was found to be 81%, 73%, 81%, and 64%.

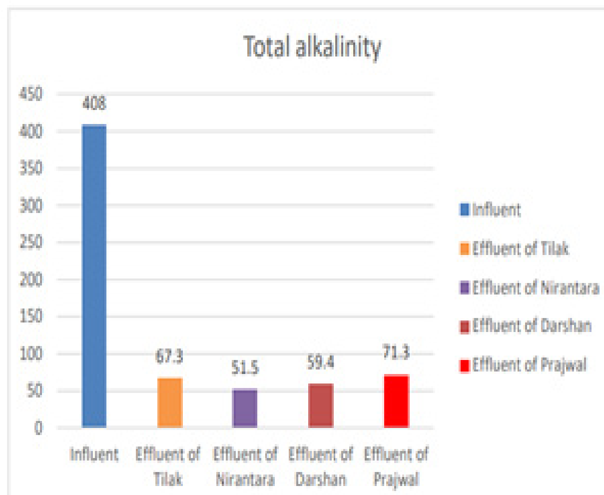


Graph 4. Sodium graph.

It shows in the graph 3, that Nickel levels after treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, at a discharge rate of 20ml/min. The influent Nickel value of 0.03mg/l has been decreased to 0.01, 0.011, 0.014, and 0.012mg/l, respectively, for each treatment. The efficiency of Nickel removal was found to be 67%, 63%, 53%, and 60%.

The graph 4, show that influent Sodium value of 60mg/l has been decreased to 36, 24, 22, and 34mg/l, respectively, for each treatment. The efficiency of Sodium removal was found to be 40%, 60%, 63%, and 43% after treatment.

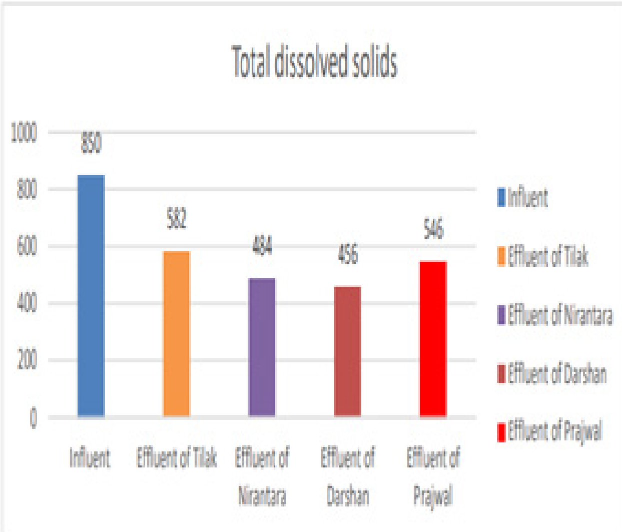
From the graph 5, it can be observed that the influent Total alkalinity value of 408mg/l has been decreased to 67.3, 51.5, 59.4, and 71.3mg/l, respectively, for each treatment. The efficiency of Total alkalinity removal was found to be 84%, 87%, 85%, and 83% after treatment with Arka Tilak, Arka Darshan, Arka Nirantara, and Arka Prajwal, respectively.



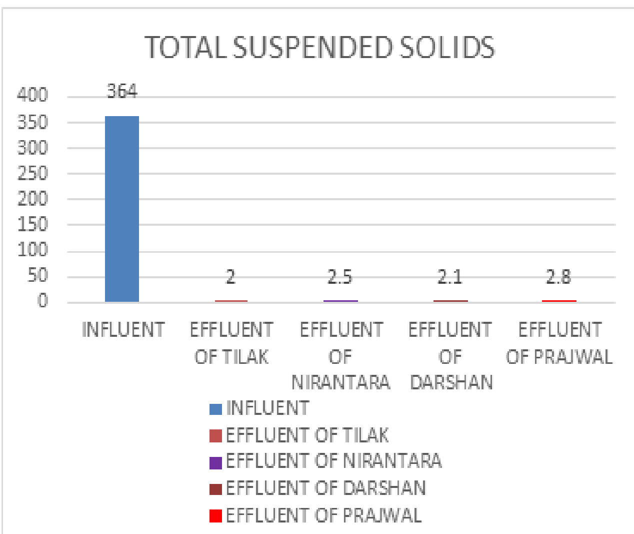
Graph 5. Total alkalinity graph.

From the graph 6, it can be observed that the Total Dissolved Solids (T.D.S.) levels decreased significantly after treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, at a discharge rate of 20ml/min. The influent T.D.S. value of 850mg/l has been decreased to 582, 484, 456, and 546mg/l, respectively, for each treatment. The efficiency of T.D.S. removal was found to be 32%, 43%, 46%, and 36%.

From the graph 7, it can be observed that the efficiency of Total suspended solids was found to be 99.4%, 99.3%,



Graph 6. Total dissolved solids graph.

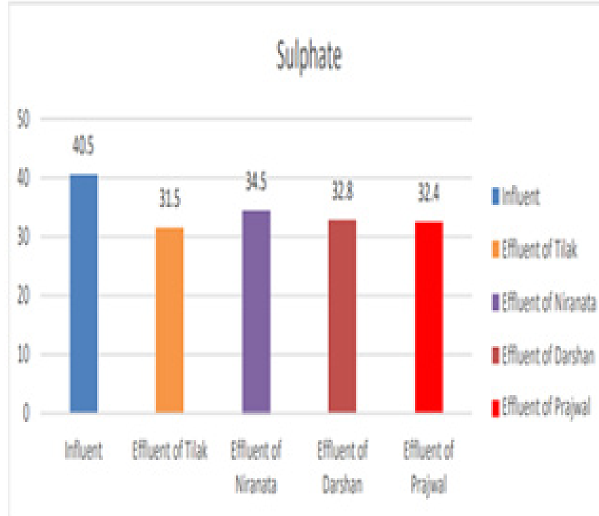


Graph 7. Total suspended solids graph.

99.4% and 99.2% for wastewater treated with with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, respectively at a discharge rate of 20ml/min.

The influent Total Suspended Solids value of 364mg/l has been decreased to 2, 2.5, 2.1, and 2.8mg/l respectively for each treatment.

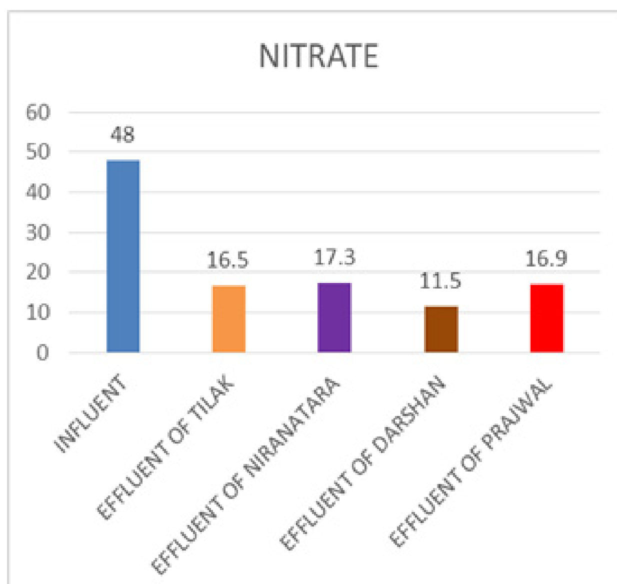
From the graph 8, there is a reduction in Sulphate. The influent Sulphate concentration is 40.5mg/l, which was reduced to 31.5, 34.5, 32.8, and 32.4mg/l by treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, respectively, at a discharge rate of 20ml/min.



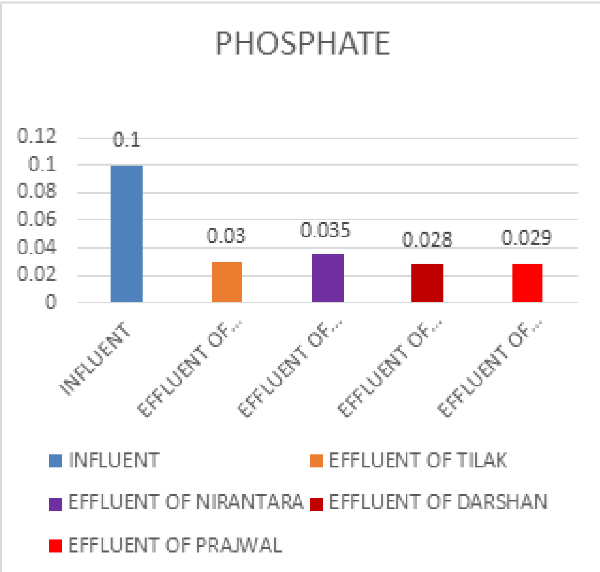
Graph 8. Sulphate graph.

The efficiency of Sulphate reduction is 22%, 15%, 19%, and 20% by treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, respectively.

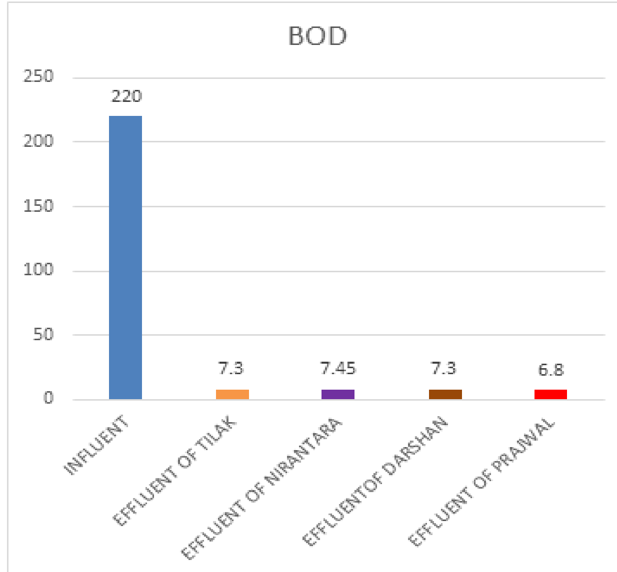
From the graph 9 data, it is evident that the Nitrate concentration has reduced. The initial Nitrate value in influent is 48mg/l, which has been decreased to 16.5, 17.3, 11.5, and 16.9mg/l after the treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, respectively.



Graph 9. Nitrate graph.



Graph 10. Phosphate graph.



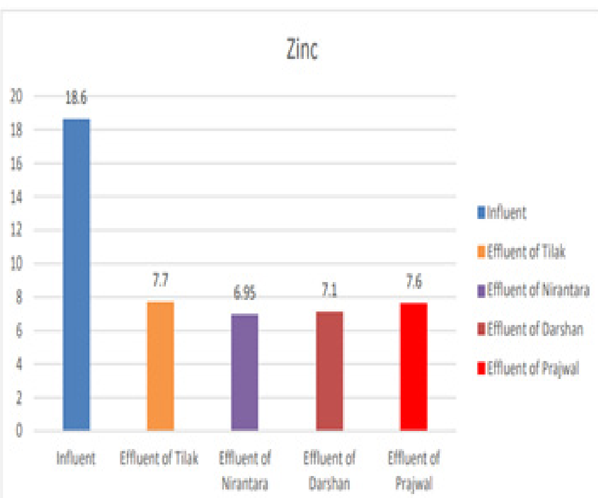
Graph 12. BOD graph.

The efficiency of Nitrate reduction is 66%, 64%, 76.04%, and 65% after the treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, respectively, at a discharge rate of 20ml/min.

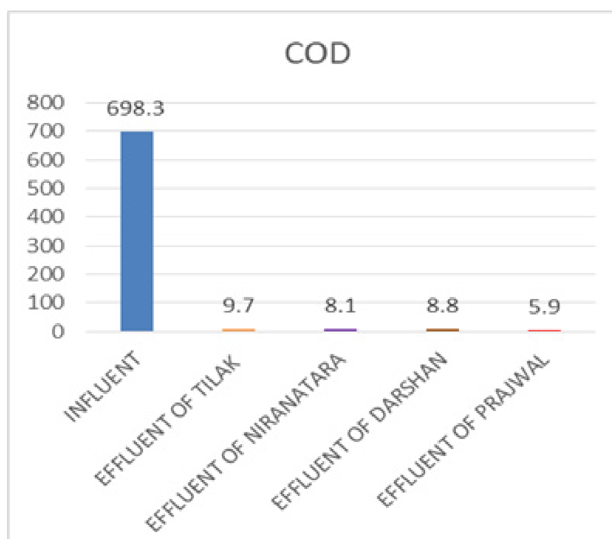
The efficiency of Phosphate reduction was 70%, 65%, 72% and 71% which is shown in the graph 10.

From the graph 10, we observed a decrease in Phosphate levels. The influent Phosphate level of 0.1mg/l decreased to 0.03, 0.035, 0.028 and 0.029mg/l after treatment with Arka Tilak, Arka Nirantara, and Arka Darshan, respectively at a discharge rate of 20ml/min.

From the graph 11, it can be observed that there is a decrease in the concentration of Zinc. The influent Zinc concentration is 18.6mg/l which has been reduced to 7.7, 6.95, 7.1, and 7.6mg/l by treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, respectively, at a discharge rate of 20ml/min.



Graph 11. Zinc graph.



Graph 13. COD graph.

The efficiency of Zinc removal is reduced to 58.14%, 56.53%, 59.2%, and 59.06% by treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, respectively, when the wastewater is treated at a discharge rate of 20ml/min.

Based on the graph 12, it is observed that there is decrease in BOD. The influent BOD value of 220mg/l is decreased to 7.3, 7.45, 7.3 and 6.8mg/l after the treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal, respectively at 20ml discharge rate. The efficiency of BOD reduction was 96.7%, 96.6%, 96.7% and 96.9% respectively.

It is observed in the graph 13, that there is decrease in COD. For influent COD value is 698.3mg/l, which has been decreased to 9.7, 8.1, 8.8 and 5.9mg/l after the treatment with Arka Tilak, Arka Nirantara, Arka Darshan, and Arka Prajwal with an efficiency of 98.6%, 98.8%, 98.7% and 99.1% respectively.

5.0 Conclusions

- This treatment plant seems to be viable alternative to conventional wastewater treatment technology especially suitable for small to medium sized community.
- Treatment method gave an efficiency of 98% in COD removal and 96% in BOD removal.
- Treatment plants gave an efficiency of 99% in TSS and 46% in TDS removal.
- Nitrates and phosphates which causes eutrophication in water bodies has been reduced to 76% and 72% respectively. Heavy metals like chromium are reduced up to 81%.
- The efficiency of the treatment unit can be increased by increasing the retention time of the wastewater in each unit and by increasing the depth of the soil in the treatment unit.
- It requires low maintenance, working expenses as compared to conventional wastewater treatment plant.

6.0 References

1. Karhade VR, Kamble AL, Vangujare SB, Wadgaonkar PS, Gadekar GS, Godihal J. Environmental Impact Assessment of Anthropogenic Activities and Conceptual Restoration Strategy for Kham River in Aurangabad, India. Curr. World Environ. 2020; 15(3):663–82.
2. Mehmet K, Nurdan B, Adem, An Experimental study on Treatment of Domestic Wastewater by Natural soil. Eng. Sci. 2020; 15(4):196–208.
3. Sam Cherian, M. Margarida Oliveira Transgenic plants in phytoremediation: Recent advances and new possibilities. Natl. Libr. Med. 2005; 39(24):9377–90.
4. Siti hanna elias, Maketab mohamed, Aznah nor-anuar, Khalida muda, Mohd arif hakimi mat hassan, Mohd. nor Othman, Shreeshivadasan chelliapan. Water Hyacinth Bioremediation for Ceramic Industry Wastewater Treatment-Application of Rhizofiltration System. Sains Malaysiana. 2014; 43(9):1397–1403.
5. M.A. Maine, Nutrient and metal removal in constructed wetland for wastewater treatment from metallurgical industry. Ecol. Eng. 2006; 26(4):341–347.
6. U. Stottmeister, A. Wiebner, P. Kuschk, U. Kappelmeyer, M. Kastner, O. Bederski, R.A. Muller and H. Moormann, Effects of plants and microorganisms in constructed wetlands for wastewater treatment in UFZ Centre for Environmental Research, Leipzig-Halle, Germany. 2003; 22(1-2):93–117.
7. D.O. Olukanni, J.J. Ducoste, Optimization of Waste Stabilization Pond Design for Developing Nations using Computational Fluid Dynamics. Ecol. Eng. 2011; 37(11):1878–1888.
8. P.S. Navaraj, Anaerobic Waste Stabilization Ponds: A Low-cost Contribution to a Sustainable Wastewater Reuse Cycle. Appl. Biochem. Biotechnol. 2005; 109(1-3):241–52.
9. A. Yasar, Rehabilitation by constructed wetlands of available wastewater treatment plant in Salkhnin, Ecol. Eng. 2007; 29(1):27–32.