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Pleasant Valley Lake Restoration through Floating Treatment Wetland

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ABSTRACT

The present investigation was undertaken to assess the water quality of thePleasant Valley Lake, Jubilee hillswhich is a man-made lake originally designed for drinking water purposes. But the lake was disappeared from past few years due to dumped garbage, domestic sewage and the release of industrial effluents. In recent years, the lake was being cleaned with an eco-friendly hydroponic floating treatment wetland technique. This study was conducted to examine the efficiency of floating treatment wetland in improving the water quality of the pleasant valley lake. The water samples were collected before (on 2nd February 2020 at 8:00AM) and every 15 days (17th feb 2020, 7th March 2020, 22nd March 2020) after the installation of FTW and analyzed for the Physico-chemical quality, microbiological data and heavy metal concentration with the use of standard analytical techniques for water quality and the results were compared with the prescribed acceptable limits for drinking water. Of the different water quality parameters, the results showed that the pH, TS, TSS, TDS, BOD, alkalinity and Total hardness are within the prescribed limits while COD and DO are above and below the standard limits respectively. Microbiological analysis revealed that 80% of the strains were gram negative and most of the bacterial strains belong to class proteobacter, water is not suitable for human consumption. The heavy metal concentrations indicated the presence of Cu, Cd, Zn and Ni. The average concentration of metals in treated water is less than that of the untreated water. The comparison of heavy metals in the pleasant valley lake with the drinking water standards and those in water used for agriculture suggests that the mean concentration of Cu and Zn lies within the standard where-as Cd and Ni are above the standards. The results indicated that floating treatment wetlands are effective in improving the water quality of the lake.

Keywords: *Floating Treatment Wetland, Pleasant Valley Lake, physico-chemical, microbiological, heavy metals*

Introduction

Lakes are important assets for the study of ecosystem dynamics [1] that normally comprises catchment areas, inlet and outlet of the lake, associated ecosystems and biodiversity (Wikipedia). Lakes are vital resources for aquatic wild life and human needs and a source of freshwater for plants and animals (WWF). They create an ecosystem by maintaining the water cycle (USGS), acts as biodiversity conservation area and as natural balance preserving reservoirs. Hyderabad was once known as "the city of lakes" as it had a large number of water bodies such as lakes, reservoirs and ponds.But most of them are vanished due to encroachment, industrial development, release of sewage, illegal construction activites, ganesh idol immersions, dumping of garbage and fast urbanization in the last two decades which resulted in disappearance of lake ecosystem that has detoriated the lake water quality (Wikipedia). Many lakes in Hyderabad had and have been diminishing due to eutrophication leading to the toxicity to humans and animals via ingestion, algal growth, decrease in the concentration of oxygen suffocating aquatic organisms that lead to the death of aquatic life[2]. Hence it is essential to treat the lake water before releasing into the environment. Several mechanical techniques were employed for their treatmentto generate high quality water but they are expensive to maintain, require skill operators, produce economic pressures [3]. Hence, scientists led to the discovery of floating treatment wetlands which is a cost-effective[4-5] and environmental friendly hydroponic system[6]. Floating treatment wetlands have attained tremendous popularity for water purification purposes [7]. It is a soil less hydroponic phyto-remediation technique that works on the principle "nature itself to clean nature" that cleans and purifies the polluted water body [8]. FTW's involves the growth of emergent wetland plants on a buoyant-raft structure that floats over the water surface[9].

Construction of floating treatment wetlands

Floating treatment wetlands structure is simple and effective measuring around 3000 sq ft with thermocoal on all four sides and plastic bottles attached to ensure that they remain afloat. FTW's comprises four layers. Floatable bamboo forms its base over which Styrofoam cubicles are placed. The third layer consists of gunny bags and the gravel forms the final layer in which aquatic plants known to absorb pollutants are planted with cleaning agents which are typically plants such as vetivers, cattalis, canna, bulrush, citronella, hibiscus, fountain grass, flowering herbs, tulsi and ashvagandha. The scientic names of the plants were mentioned in table 1

Table: 1 Plants used in floating treatment wetlands

Plants used in floating treatment wetland	Scientific Name
Cattalis	*Typha latifolia*
Bulrush	*Scirpoides holoschoenus*
Fountain grass	*Pennisetum setaceum*
Citronella	*Cymbopogon nardus*
Vetivers	*Chrysopogon zizanioides*
Tulsi	*Ocimum tenuiflorum*
Ashvagandha	*Withania somnifera*

Figure 1: construction of floating treatment

Wetlands

Working of floating treatment wetland

Floating treatment wetlands consists of small holes at the bottom of the base that facilitates the flow of nutrients from water to plants through biological uptake process. The submerged roots from buoyant mat reaches the nutrient rich lake where the plants absorb both organic and inorganic nutrients providing habitat for beneficial micro-organisms that promote the breakdown of organic matter by decomposition in the root system. The absorbed nutrients get immobilized through absorption and accumulation by roots. The contaminants from the roots get translocates and are accumulated in the above surface plant. Higher transpiration rate of plants during warmer periods support high mass flux of pollutants to the above ground biomass.

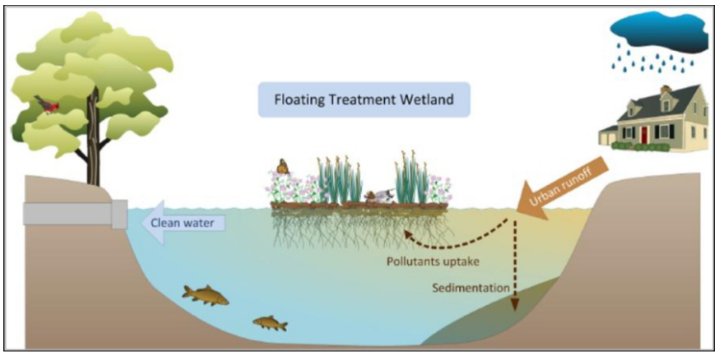


Figure 2: Flow chat for the construction of floating treatment wetland

Study area

Telangana, located in southern India, is the eleventh-largest state by area and the twelfth-most populous, covering 112,077 km^2. As per the 2011 Census, the state had a population of approximately 35.19 million. Hyderabad, the capital and largest city of Telangana, spans 650 km^2 on the Deccan Plateau along the banks of the Musi River. It is a major metropolitan hub and, according to the 2011 Census, the fourth-most populous city in India, with around 6.9 million residents [10]. The present study was conducted on the Pleasant Valley Lake. The lake was unidentified in the past years due to garbage dump and release of untreated effluents by the residentials of the surrounding area. Pleasant valley lake is situated in senior police officers club, MP and MLA'S colony, road number 10, jubilee hills at 17°26'31.4₺N latitude and 78°25'00.9₺E longitude. Pleasant valley is being maintained by Dhruvansh, an NGO working for the protection of water bodies since 2016.

Figure 3: the satellite view and default view of the pleasant valley lake.

Figure 4: contamination of the pleasant valley lake before the installation of floating treatment wetlands

Figure 5: the present status of the pleasant valley lake after the installation of the floating treatment wetland

Methodology

Sample collection: The grab samples were collected to analyze physico-chemical, microbiological and heavymetal analysis before (on 2nd February 2020 at 8:00AM) and every 15 days (17th feb 2020, 7th March 2020, 22nd March 2020) after the installation of FTW in the pleasant valley lake. The samples were collected in sample rinsed 2L polyethylene bottles for the physico-chemical analysis, 100ml microbottles sterilized at 121°C temperature, 15 lbs pressure for 15 min for microbiological analysis and HNO_3 rinsed 250ml polyethylene bottles for the analysis of heavy metals.

Sample preservation: The following preservatives were added for the samples after the collection to preserve them

Table 2: preservatives added during the collection of samples in the pleasant valley lake.

S.No	Experiment	Preservative	Holding Time
1	P H	No preservative	2 hours
2	Total Solids (mg/l)	No preservative	7 days
3	Total Suspended solids (mg/l)	No preservative	7 days
4	Total Dissolved Solids (mg/l)	No preservative	7 days
5	Alkalinity (mg/l)	No preservative	24 hours
6	Total Hardness (mg/l)	HNO_3	6 months
7	Dissolved Oxygen (mg/l)	Fixed onsite by wrinkler's method	8 hours
8	Biological Oxygen Demand (mg/l)	Refrigerate at 4°C	6-48 hours
9	Chemical Oxygen Demand (mg/l)	1ml H_2SO_4	7 days
10	Microbiological	Refrigerate at -8°C	-
11	Heavy Metals	1ml HNO_3	6 months

SAMPLE ANALYSIS

The water samples were analyzed for the following parameters

1. Physico-chemical analysis: p H, TS, TSS, TDS, Alkalinity, total hardness, dissolved oxygen, BOD, COD.
2. Microbial analysis: coliforms and *E.coli*.
3. Heavy metal analysis: Copper (Cu), Cadmium (Cd), Zinc (Zn), Nickel (Ni).

Table 3: methods and equipment used for carrying out the physic chemical analysis

S.no	Parameter	Method	Equipment
1.	pH	Electrometric	pH meter
2.	Total solids	Gravimetric	Hot air oven
3.	Total dissolved solids	Gravimetric	Hot air oven
4.	Total suspended solids	Gravimetric	Hot air oven
5.	Alkalinity	Titration with sulphuric acid	Titrimetry
6.	Total hardness	Titration with EDTA	Titrimetry
7.	BOD	3 days incubation	Incubation
8.	COD	Digestion followed by titration	COD digester
9.	DO	Winkler's method	Titrimetry
10.	Escherichia coli	Spread plate	Autoclave, laminar air flow
11.	Coliform	Spread plate	Autoclave, laminar air flow
12.	Copper	Digestion with HNO_3	Atomic absorption spectrophotometry
13.	Cadmium	Digestion with HNO_3	Atomic absorption spectrophotometry
14.	Nickel	Digestion with HNO_3	Atomic absorption spectrophotometry
15.	Zinc	Digestion with HNO_3	Atomic absorption spectrophotometry

Results and Discussion

The findings of this study offer valuable insights into the physicochemical characteristics, microbial diversity, and heavy metal contamination in Pleasant Valley Lake, evaluated against established water quality standards. These results contribute to understanding the lake's ecological health and potential risks to aquatic life and human consumption.

Physico-chemical analysis

The average values of untreated (before FTW) and treated (after FTW) water samples of the pleasant valley lake were analyzed for all the parameters represented in the table 1. These values are compared with the BIS standards of drinking water quality in table 2.

Table 4: average Values of different physico chemical parameters of both untreated and treated water samples of the Pleasant valley lake

Parameter	Average of untreated water sample of the pleasant valley lake	Average of treated water sample of the pleasant valley lake
pH	7.84	7.55
TS (mg/l)	192	188.2
TDS (mg/l)	148	145.5
TSS (mg/l)	44	42.75
Alkalinity (mg/l)	74	37.5
Hardness (mg/l)	370	265.5
DO (mg/l)	5.6	2.3
BOD (mg/l)	8.4	1.12
COD (mg/l)	264.8	289.6

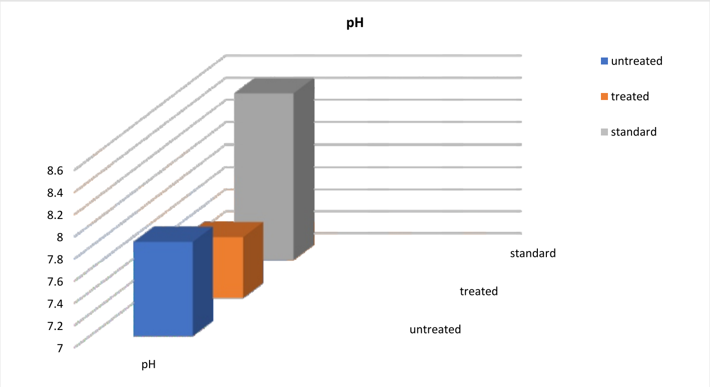
Table 5: comparison of physico chemical parameters with the prescribed standards.

SR. NO.	PARAMETER	UNTREATED	TREATED	WHO STANDARDS	INDIAN STANDARDS	EPA STANDARDS
01	**pH**	7.85	7.55	6.5-9.5	6.5-8.5	6.5-9.5
02	**TS(mg/l)**	192	188.2	-	20-500 ppm	-
03	**TSS(mg/l)**	44	42.75	-	100 ppm	-
04	**TDS(mg/l)**	148	145.5	259-500	500 ppm	500 ppm
05	**Alkalinity(mg/l)**	74	37.5	100 ppm	200 ppm	-
06	**Hardness(mg/l)**	370	265.5	200 ppm	300 ppm	<200 ppm
07	**DO(mg/l)**	5.6	2.3	7.5	5	
08	**BOD(mg/l)**	8.4	1.12	6	30	5
09	**COD(mg/l)**	264.8	289.6	10	250	40

[WHO, USEPA, Indian standard, National primary drinking water regulation, Drinking water contaminants USEPA].

pH

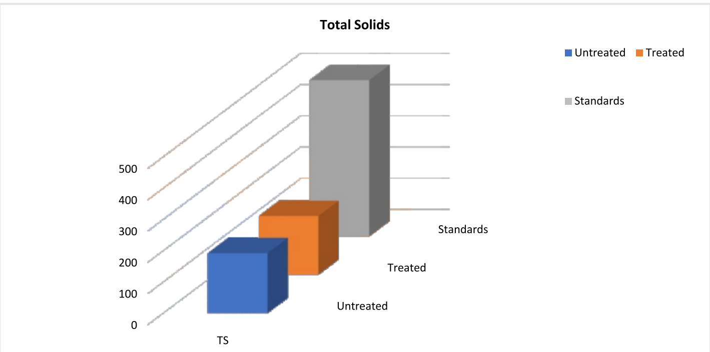
The pH of the untreated water sample was found to be 7.85 and treated sample was found to be 7.55. since, the pH of the treated water is less than that of the untreated water indicates that the floating treatment wetlands are efficient in the removal of pH. The pH values when compared with the BIS standards (6.5 to 8.5) are within the permissible range of drinking water quality.



Graph 1: Graphical representation of pH and standards.

Total Solids

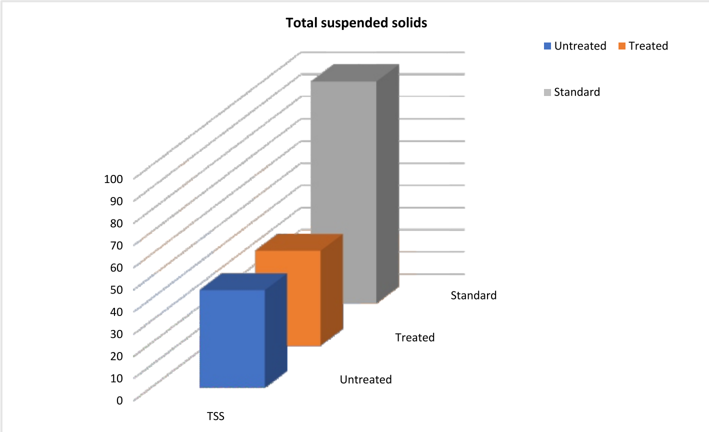
The total solids concentration in untreated water sample was found to be 192 ppm, whereas the concentration got decreased to 188.2 ppm in the treated water sample due to the deposition of solids in between the root layers or entrapment of solids in the root mat. The TS concentration was found to be within the permissible range of BIS drinking water quality standards (20-500 ppm). The comparison of Total solids with the standards is represented in the graph 2.



Graph 2: Graphical representation of total solids concentration and standards

TOTAL SUSPENDED SOLIDS

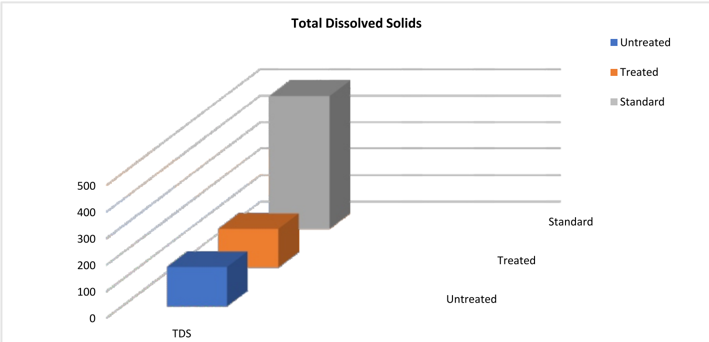
The TSS levels in untreated water sample was found to be 44 ppm and treated water sample was found to be 42.75 ppm. TSS are mainly removed by filtration and settling process in floating treatment wetland. The ideal condition for particle sedimentation was created by free water layers and minimized turbulence in between root mat and system's bottom [10].



Graph 3: Graphical representation of TSS and standards.

Total Dissolved Solids (TDS)

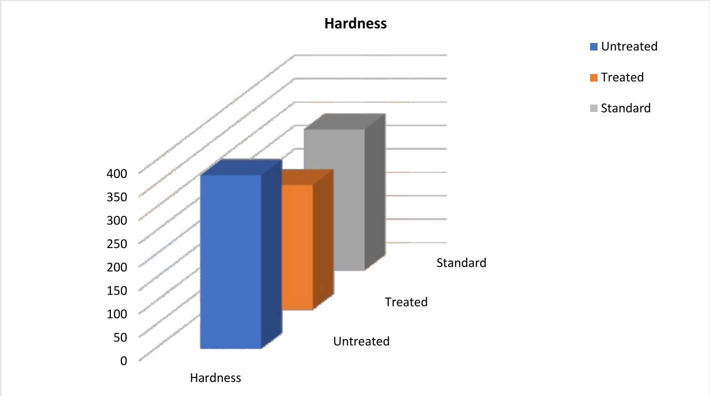
The TDS concentration in the untreated water sample was recorded at 148 ppm, which can be attributed to the accumulation of decomposed organic matter from aquatic plants and animals (*Quveshimatva Umerfarug*). In contrast, the treated water sample exhibited a slightly lower TDS concentration of 145.5 ppm. Both values fall well within the permissible limit of 500 ppm set by the Bureau of Indian Standards (BIS) for drinking water quality. A comparative analysis of TDS levels with the prescribed standards is illustrated in Graph 4.



Graph 4: Graphical representation of TDS and standards.

Hardness

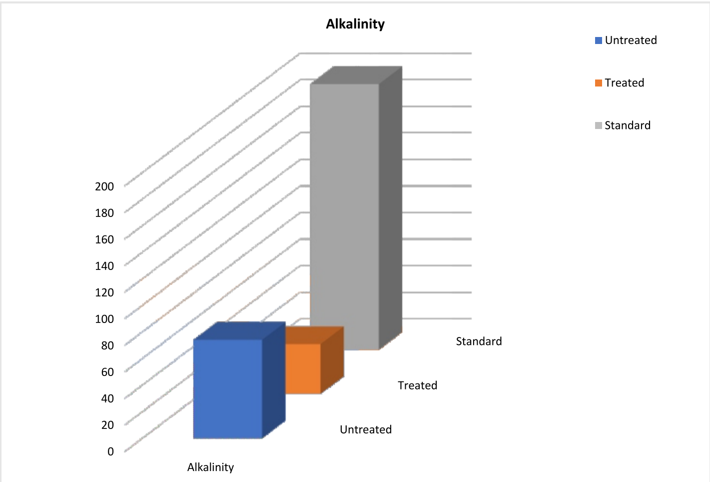
The Total hardness of untreated water sample was found to be 370 ppm whereas in the treated water sample it was reduced to 26.5 ppm which is in the permissible range of BIS drinking water quality standards (300 ppm).The eutrophication of lakes,Ca,Mg serves as the nutrients for the floating treatment wetland plants and get absorbed into the roots through the process of rhizofiltration and thus the levels of Ca,Mg was decreased in the lake. Comparision of hardness concentration with the standards are represented in the graph 5.



Graph 5: Graphical representation of Hardness and standards.

Alkalinity

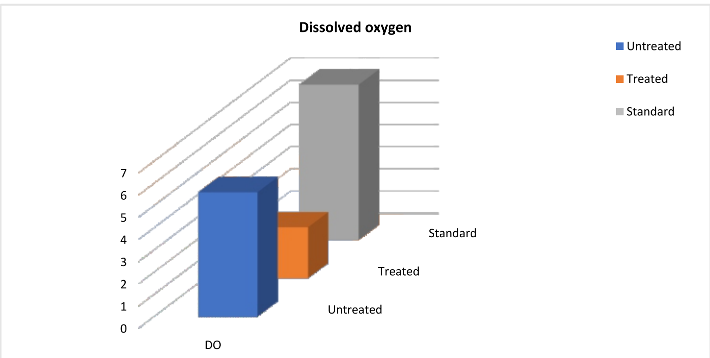
The alkalinity levels in untreated water sample was found to be 74 ppm and it dropped down to 37.5 in the treated water sample which are in the permissible limit (200 ppm). Comparision of alkalinity with the standards are represented in the table 6.



Graph 6: Graphical representation of alkalinity and standards.

Dissolved Oxygen

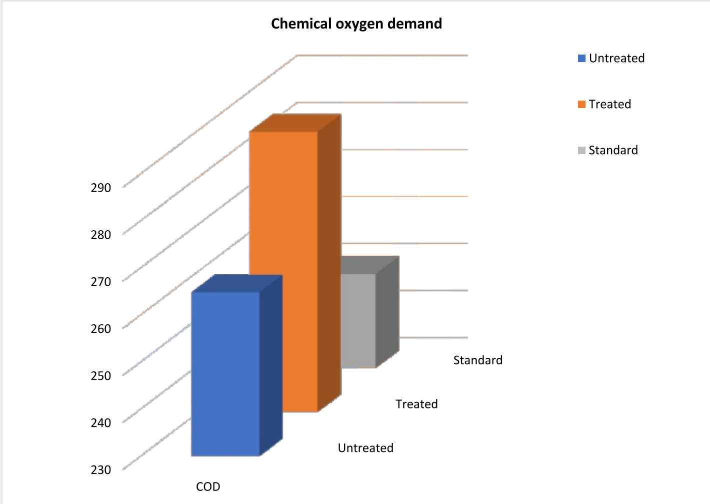
The maximum concentration of oxygen that can dissolve in water is dissolved oxygen.oxygen levels are contributed by the aeration action of wind and the photosynthetic activity of aquatic plants . DO levels in the untreated water sample was found to be 5.6 and it got decreased to 2.3 in treated water sample. This is due to the replacement of aerators in the lake. The Comparision of DO levels with the standards are represented in the graph 7. the treated water sample which are in the permissible limit (200 ppm). Comparision of alkalinity with the standards are represented in the table 6.



Graph 7: Graphical representation of DO concentration and standards.

Chemical Oxygen Demand

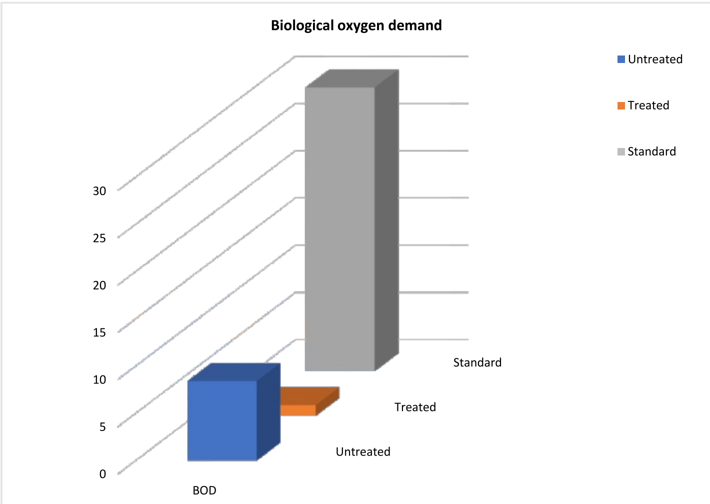
The COD for untreated water sample was found to be 264.8ppm and the levels are further increased in treated water sample to 289.6 ppm which are high according to the BIS standards (250 ppm). Higher COD levels indicates greater amount of oxidizable organic material in lake, which will reduce dissolvedoxygen.



Graph 8: Graphical representation of COD and standards

Biological Oxygen Demand

The BOD levels in untreated water sample was found to be 8.4 ppm and it was dropped down to 1.12 ppm in treated water sample. In earlier reports it was stated that increase in the BOD values are due to the high bacterial activity and heavy input of organic matter in lake water before treatment [11]. Comparision of BOD with the standards are represented in the graph 9.



Graph 9: Graphical representation of BOD and standards.

Microbial Analysis

The serial dilution method was employed to reduce the number of bacterial colonies and facilitate the isolation of individual colonies. A total of five bacterial strains were successfully isolated and streaked on separate nutrient agar plates, which were subsequently maintained at 4°C for regular use. These five bacterial colonies were designated as HOU-1, HOU-2, HOU-3, HOU-4, and HOU-5.To characterize the bacterial isolates, nutrient agar medium was used to assess morphological features such as size, shape, color, and nature of colonies.Gram staining was performed to differentiate between Gram-positive and Gram-negative bacteria.

The analysis revealed that 80% of the strains were Gram-negative, which is consistent with previous findings. Notably, studies have frequently reported that Gram-negative bacteria dominate aquatic environments[12-13].During Gram staining, the isolated bacteria exhibited a pink coloration, indicating their Gram-negativenature. Morphologically, they were observed as small, rod-shaped organisms. Furthermore, motility tests confirmed that all isolates were motile, aligning with earlier reports [14-15].Most of the bacterial strains identified in this study belonged toclass Proteobacteria, which reinforces previous research findings [16]. Proteobacteria are among the most predominant microorganisms found in global water systems, highlighting their significant role in aquatic microbial communities.The morphological characteristics of the isolated bacteria are detailed in Table 6, while their colony structures are visually represented in Figure 6.

Table 6: Morphological Characteristics of the isolated bacteria grown on NA at 37°C.

Isolates	CS	CC	CE	CM	App	Cell arrangement	Gram reaction	Suspect Organism
HOU-1	Cir	CW	Flat	Entire	Opaque	Short rods	Negative	*Escherichia coli*
HOU-2	Cir	w	Flat	Entire	Opaque	Short rods	Negative	*Escherichia coli*
HOU-3	Cir	CW	Flat	Entire	Opaque	Short Rods	Negative	*Escherichia coli*
HOU-4	Cir	CW	Flat	Entire	Opaque	Short Rods	Negative	*Escherichia coli*
HOU-5	Irr	CW	Raised	Entire	Opaque	Rod shaped	Positive	*Bacillus sp.*

CS: Colony Shape, CC: Colony Colour, CE: Colony Elevation, CM: Colony Margin, APP: Appearance, Cir: Circular, Irr: Irregular, CW: Creamish White

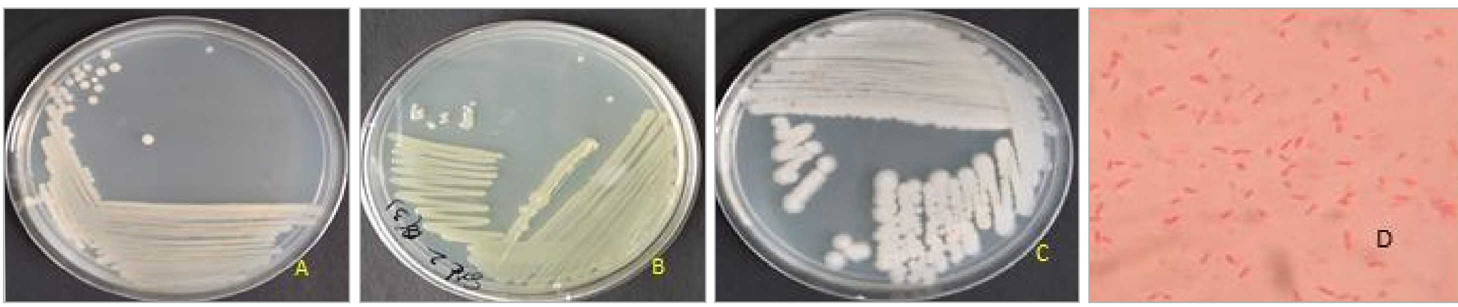


Figure 6: A. HOU-1 bacterial colonies on nutrient agar; B. HOU-3; C. HOU-5; D. Gram staining.

The bacterial isolates HOU-1, HOU-2, HOU-3, and HOU-4 were identified as Gram-negative, rod-shaped bacteria, while HOU-5 was found to be Gram-positive, rod-shaped. Based on morphological and biochemical characteristics, HOU-5 closely resembles *Bacillus* sp., which has also been previously isolated from water systems by several researchers [17]. The results of the catalase, oxidase, MR, and indole tests for *E. coli* isolates were positive, whereas the V-P test was negative, aligning with the findings of previous studies [18-19]. The biochemical characteristics of the bacterial isolates are summarized in Table 7.

Table 7: Biochemical Characteristics of the isolated bacteria

Bacterial Isolates	Catalase	Oxidase	Citrate	Indole	Urease	Gelatinase	Mot	MR	VP
HOU-1	+	+	-	+	-	-	+	+	-
HOU-2	+	+	-	+	-	-	+	+	-
HOU-3	+	+	-	+	-	-	+	+	-
HOU-4	+	+	-	+	-	-	+	+	-
HOU-5	+	+	+	-	-	+	+	+	-

Key: (+) Showing activity, (-) No activity, Mot: Motility test, MR: Methyl Red test, VP: Voges Proskauer.

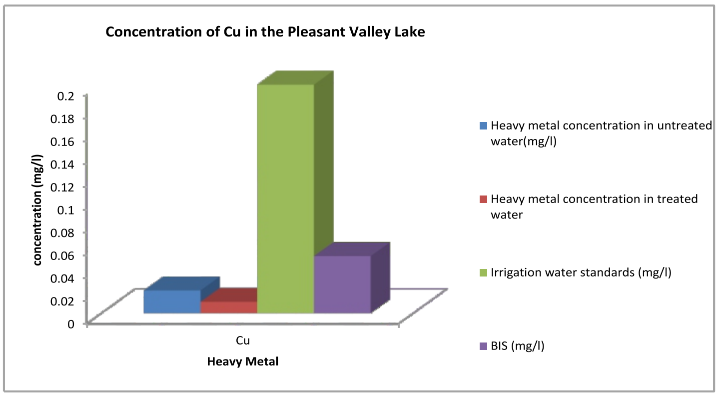
Heavy Metal Analysis

This study aimed to examine the concentration of heavy metals in the water samples using an atomic absorption spectrophotometer. The results indicated the presence of copper (Cu), cadmium (Cd), zinc (Zn), and nickel (Ni) in the water samples. The concentration levels of these metals were analyzed and compared against the prescribed standards for water quality to assess their potential impact on health and the environment.

Table 8: Heavy metal concentrations in the untreated and treated water of the pleasant valley lake with the prescribed standards of drinking water and irrigation standards.

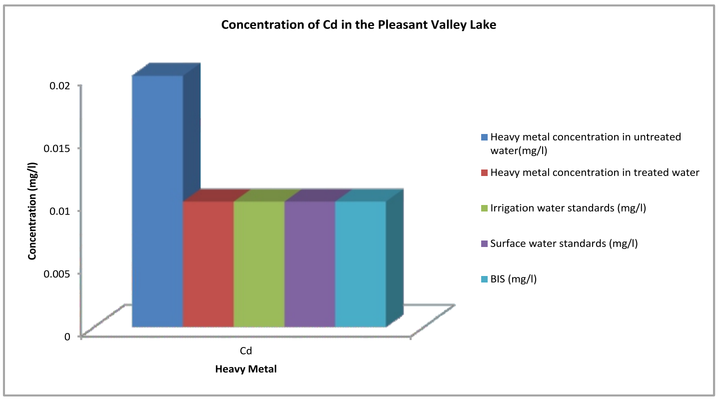
S.No	Heavy metal	Heavy metal concentration in untreated water (mg/l)	Heavy metal concentration in treated water (mg/l)	Irrigation water standards (mg/l)	Surface water standards (mg/l)	BIS (mg/l)
1	Cu	0.02	0.01	0.2	-	0.05
2	Cd	0.02	0.01	0.01	0.01	0.01
3	Pb	ND	ND	5.00	0.005	
4	Zn	0.211	0.190	2.00	-	5
5	Ni	0.19	0.11	0.2	0.144	0.02
6	Cr	ND	ND	0.1	0.16	0.1

Cu, Copper; Ar, Arsenic; Cd, Cadmium; Cr, Chromium; Zn, Zinc; Fe, Iron; Ni, Nickel; Mn, Manganese; BIS, Bureau of Indian Standards.



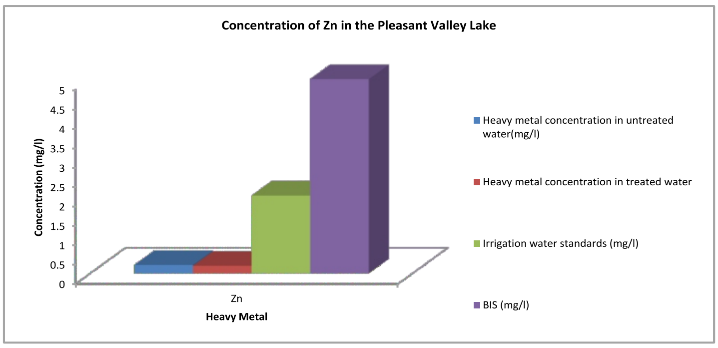
Graph 10: comparison of Cu in the untreated and treated water of the pleasant valley lake with the prescribed drinking water and irrigation water standards.

The concentration of copper (Cu) in the untreated water is 0.02 mg/l while the concentration of Cu in the treated water is 0.01 mg/l. Since, the concentration of Cu in the treated water is less than the untreated water indicates that the floating treatment wetlands are efficient in the removal of copper. As the concentration of copper in the pleasant valley lake is less than the standards prescribed by BIS and irrigation standards, the water can be used for gardening and domestic purposes apart from drinking.



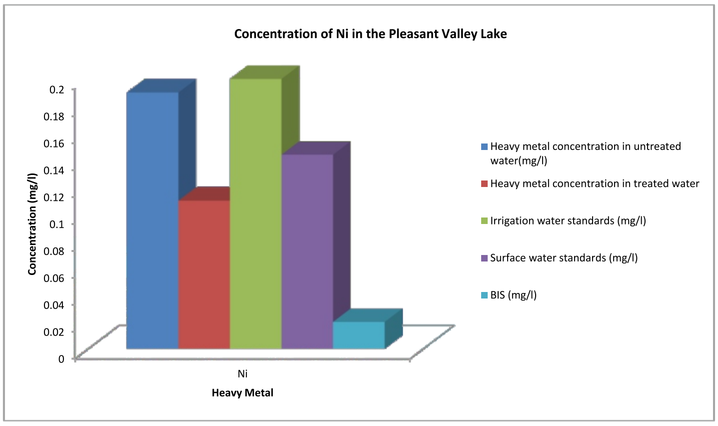
Graph 11: comparison of Cd in the untreated and treated water of the pleasant valley lake with the prescribed drinking water and irrigation water standards

The concentration of Cadmium (Cd) in the untreated water is 0.02 mg/l while the concentration of Cd in the treated water is 0.01 mg/l. Since, the concentration of Cd in the treated water is less than the untreated water indicates that the floating treatment wetlands are efficient in the removal of cadmium. As the concentration of cadmium in the treated water of the pleasant valley lake is less than the standards prescribed by BIS and irrigation standards, the water can be used for gardening and domestic purposes apart from drinking.



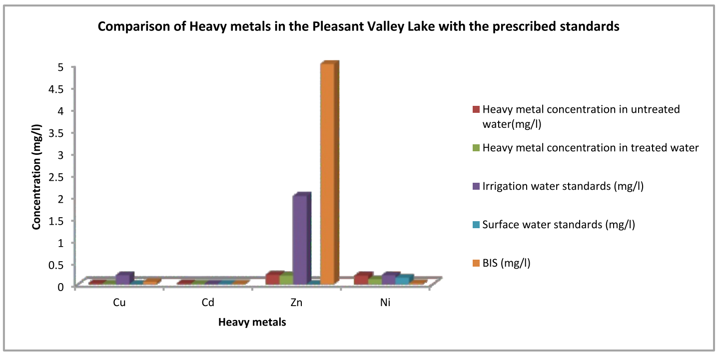
Graph 12: comparison of Zn in the untreated and treated water of the pleasant valley lake with the prescribed drinking water and irrigation water standards

The concentration of Zinc (Zn) in the untreated water is 0.211 mg/l while the concentration of Zn in the treated water is 0.19 mg/l. Since, the concentration of Zn in the treated water is less than the untreated water indicates that the floating treatment wetlands are efficient in the removal of Zinc. As the concentration of Zinc in the pleasant valley lake is less than the standards prescribed by BIS and irrigation standards, the water can be used for gardening and domestic purposes apart from drinking.



Graph 13: comparison of Ni in the untreated and treated water of the pleasant valley lake with the prescribed drinking water and irrigation water standards

The concentration of Nickel (Ni) in the untreated water is 0.19 mg/l while the concentration of Ni in the treated water is 0.11 mg/l. Since, the concentration of Cu in the treated water is less than the untreated water indicates that the floating treatment wetlands are efficient in the removal of Nickel [20-21]. As the concentration of Nickel in the pleasant valley lake is more than the standards prescribed by BIS and less than the irrigation standards, the water can be used for gardening and domestic purposes apart from drinking.



Graph 14: comparison of the concentration of heavy metals in the untreated and treated water of the pleasant valley lake with the prescribed drinking water and irrigation water standards

The results showed that the average concentration of metals in treated water is less than that of the untreated water indicates that the floating treatment wetlands are efficient in the removal of heavy metals [22-23]. The average concentration of the metals before the treatment were more than the prescribed standards while the concentration of metals after the treatment with floating treatment wetlands are less than the prescribed drinking water standards and the irrigation water standards, the water can be released into the environment and can be used for agricultural and domestic purposes.

Conclusion

Pleasant Valley Lake, Jubilee hills was once a source of drinking water.

Due to the anthropogenic activities near the lake, the lake was invisible for the past few years. The lake was being cleaned by the floating treatment wetland technique which is an environmental friendly, cost effective hydroponic technique. This paper concludes that the physico chemical parameters for the pleasant valley lake were analyzed and Compared with BIS standards. The results showed that pH, TSS, TDS, TS, alkalinity, hardness, BOD are within the acceptable limits.Dissolved oxygen was found to be below acceptable level. This might be due to the replacement of aerators in the lake.Chemical oxygen demand was above acceptable level. To mitigate this, a greater number of aerators are to be placed in the lake to support the aquatic life. Microbial analysis revealed that 80% of the strains were gram negative and most of the bacterial strains belong to class proteobacter. The concentrations of heavy metals Copper and Zinc were below the standards of water quality guidelines prescribed by WHO, EPA and BIS. Since, the only source is rain water, all the heavy metal concentrations were below the standards except cadmium and nickel. The concentrations of Cadmium and Nickel were above the standards. This indicates that the contamination was once due to the developmental activities and rock weathering near the lakes. When compared to Copper, Cadmium and Nickel, the concentration of Zinc was high in the lake. Hence the lake water can be used for gardening and irrigational purposes apart from drinking. Hence it can be concluded that FTW are the promising technology which makes the water suitable for irrigation, fishing, and agricultural purposes. To make the water portable for drinking, the water must be treated effectively. Floating treatment wetland not only improves the quality of water, but it also supports aquatic life.FTW provides shelter of many migratory birds, the plants chosen for FTW are mosquito repellents (lemon grass).The different biodiversity is observed around the lake such as fishes, ducks, butterflies, bees, cranes, snakes, frogs.

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