REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

Role Of Lotus (Nelumbo Nucifera) In Phytoremediation Of Heavy Metals And Water Quality Improvement

Bhavna Mahla[1], Dr. Garima Sharma[2*]

[1]Research Scholar, Department of Zoology, Apex University, Jaipur, Rajasthan
[2*]Associate Professor, Department of Zoology, Apex University, Jaipur, Rajasthan

***Corresponding Author:** Dr. Garima Sharma
*Email: drgarimasharma178@gmail.com

Abstract-
The environment of earth is being threatened by many pollutants specially the heavy metals discharged from point and non- point sources. Removal of heavy metals from wastewater is necessary for clean the environment and ecosystem. Heavy metals are spread wildly in water effect the aquatic ecosystem and organism of ponds and lakes. The purpose of this study that the phytoremediation of pollutants caused in Ponds and lakes released by industries and agriculture waste using Nelumbo nucifera (Lotus plant). This research focus on capability of Lotus plant in water treatment by eco- friendly and sustainable methods for physiochemical pollutants and heavy metals. This phytoremediation experiment was conducted using selected concentration 25 % of different pond and lake waste water for 21 days in three different seasons of 2022 and 2023 in Rajasthan. The results showed that Nelumbo nucifera can reduced the physiochemical pollutants and heavy metals from water. The maximum reduction of TSS by 50%, COD by 39%, DO increase by 39%, TDS reduced by 30%, BOD by 27%, pH by 12 % and heavy metals (Lead : 33%, Copper : 30%, Fluoride : 22% and Nitrate : 22%). This study contribute to the application of lotus aquatic plant to heavy metals removal from moderately contaminated lake and pond. Bioaccumulation of heavy metals in lotus stem and roots by enzymes and microbes, it is affected by temperature and Ph of water. Massive roots and leaf of lotus have large surface area for reduction of physiochemical pollutants from water.

Key words- Heavy metals, Lotus, physiochemical parameters, phytoremediation, water quality.

Introduction-
Water is essential for all forms of life, there is less potable water available because of industrialization and agriculture activities done by people, due to this huge amount of waste is released into water resources. The water is contaminated by organic matters, pathogenic microbes, nutrient and hazardous chemical concentration in wastewater (Smits, 2005). Our India has rich resources of water in different forms like lakes, ponds and rivers and the rivers are more polluted according to NEERI about 70% of water resources in India are polluted (Martin 1997). Water scarcity, rising disposal cost and tougher discharge rules are highlight the growing need of wastewater treatment (Raskin, 2000). Heavy metals are used in the industry, in dyeing, and battery industry. A recent study said that these heavy metals are removed by biological and metabolic activities, these are traditional methods. These heavy metals affect the organisms on the earth even if they are present in low amounts (L. Wang et al., 2019). Heavy metal ions are present in the environment which include Pb2+. The metal ion of Pb+ can enter the food web which causes serious issues in human health (Y. Zhao et al., 2019). Today many techniques have been introduced such as reverse osmosis, membrane filtration, and ion exchange (Vardhan et al., 2019). Absorption is a useful technique for the reduction of heavy metals. But the chemicals of absorption can remain in an environment which causes health issues (Wang et al., 2015). In the Fermentation industry these absorption materials are used, these absorbents have side effects and have low efficiency (Wang et al., 2007). Pollutants on earth are present naturally due to human activities like agriculture and industry. These industries release the metals into the water by mining and refinery processes (Gardea-Torresdey et al., 1997; Srivastava et al., 2007). The heavy metals which are present in the environment are toxic to human health and the ecosystem (Shakibaie et al., 2008; Vinodhini and Narayanan, 2009). Heavy metals like Cd, Zn, Cu, Ni etc. are carcinogens which affect animals, plants and humans (N. Khellaf, M. Zerdaoui, 2009). Cr inside the animal break down the sugar, protein and fat. Cr is essential for health which means good for the body. However, an excessive amount of chromium is not good for the health. Cr inside the body for a long time can cause liver damage, ulcers, nosebleeds and kidney damage in humans. Cr even causes death in humans by cancer (ATSDR 1998).
After 1948 Rajasthan has 3.5 per cent of the industry of India (Singh. J, 2009). About 272 factories were added between 2010 and 2012 and gained the third rank in industrialisation. As the industry grew the use of natural resources so there is a reduction in the ecosystem. There is an adverse effect on the environment has been observed in the population. Humans play an important role in disturbing the ecosystem. Animals and plants are more affected by contaminated water, which is caused by the careless activity of humans but some microorganisms adapt themselves to the changed environment (Quatrochi PM, 1995). All the pollutants from industry direct and indirect poured into the rivers and lakes by human activity. Due to pollutants effect the ecosystem and human health (Jain AK et al,. 2003).). Ground water is polluted when the pollutants from surface is transferred to the groundwater. It could happen by leakage in sewage and petrol pump, by

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

landfill, excess use of fertilizer in the crops which directly transferred to the groundwater. Main compound of pollutants are arsenic and fluoride. These heavy metals are serious for health. Fluoride is condensed in ground water which is produced by volcano effect and transferred to the water which directly or indirectly way down to the ground water(Arifan et al,. 2018). Chemicals have been used in the treatment of water that also cause harmful effects on the environment (Wang et al., 2015). Adorbants have been used for reduction of heavy metals from the water (Sajayan et al., 2017). Lipo-peptides have been used for treatment of wastewater which is produced by the fermentation of bacillus subtilis with soya flour and straw flour. Lipo-peptides are eco-friendly and cheap in cost used in treatment (Chang et al., 2014; Avisar et al., 2010). Wastewater treatment also focuses on the reduction of antibodies from water. The technique has been used in the reduction of antioxidants is AOPs (Adavance oxidation process) discussed by (Garrido-Cardenas et al., 2020). Biological methods are used for the reduction of pollutants from water (Londono and Penuela, 2015; Feng et al., 2018).

Phytoremediation technique is eco-friendly and cheapest then other techniques. This technique is easy to handle and maintains is low than other technique. Low skills required for handle the phytoremediation. These plants are associated with micro-organism for reduction of heavy metals (Terry and Banuelos 2000; Mohanty et al. 2005b, Mohanty and Patra 2011; Mohanty 2015). Plants are used in water for remediation by phytoextraction (Kumar et al. 1995; Tangahu et al. 2011). Rhizomes of plants associated for filteration of pollutants in water (Dushenkov et al. 1995; Elias et al. 2014). The photosynthesis process is involved in remediation of pollutants from water and plants growth. Many plants species are used for phytoremediation are as water hyacinth, duckweeds, small water fern, and water lettuce etc. (Okunowo and Ogunkanmi 2010; Suhag et al. 2011; Rai 2008; Gupta et al. 2012; Ajibade et al. 2013; Saha et al. 2015). Lotus is a popular plant in the Asian continent like China, Australia, India, Korea, and Japan etc. which is grown in water of length 1.5 m. It is an aquatic plant which is used as an edible vegetable, and rhizome as a vegetable, for sweet food, and for medication, flowers of lotus are used for cosmetics, ornamentals etc. (Yi et al., 2002). Lotus plant seeds are containing beneficial minerals (Ibrahim and El-Eraqy, 1996). Also used for anti-inflammation, skin disorders and cancer (Chopra et al., 1956; Liu et al., 2004).

Lotus has been used for the treatment of water. Ponds containing lotus plants are eco-friendly for treating municipal domestic and industrial wastewater (Seo et al., 2008). This eco-friendly process reduces the nitrogen from the pond and nitrogen retention. The process involved in NH3 volatilization, denitrification, nitrogen fixation, microbial activity, ammonification, absorption etc. which involved the reduction of nitrogen from the wastewater. Some processes to maintain nitrogen in the pond (Vymazal, 2005, 2007; Seo et al., 2008). According to Greenway and Woolley (1999) ponds of lotus plants are also helpful in the reduction of phosphorus. For treatment of ponds others plants are used but data collection on these plants is not mentioned in previous studies. So the plants lotus which found in a tropical area. Lotus is famous among other plants which are used for the treatment of wastewater. Lotus crops grow in Asian countries for their favourable climate (Yi, Lin and Diana, 2002). Lotus plant was cut from the rhizome which was observed for two days bubbles arise from the rhizome which means it provides oxygen to the anaerobic area (J. Mevi-Schutz, W. Grosse, 1988). After the phytoremediation process by the lotus plant in water, another process has been started which is called bioremediation. The bioremediation process require microbes for reduction of contaminants from soil and water (D. Singh, A. Tiwari, R. Gupta, 2012). After the bioremediation process plants roots translocate the pollutants by the surface of roots to stem and leaf of the plant. The plant uses the essential nutrients and contaminants from water and soil for the metabolism process. Nutrients are uptake by plants that leads to the growth of plants and as the growth occurs more accumulation of pollutants in plants. Nelumbo nucifera is used for the remediation of contaminants from surface water purpose of pre-processing drinking water and live stocking. Lotus plant has unique properties for the transport of oxygen from roots to leaves which improves the BOD, COD, DO, pH, and turbidity of surface water (G. Catian, E. Scremin-Dias, 2013).

Material and methods-

Sampling-

To ensure accurate water analysis, it is essential to collect the correct volume of water, carefully selecting the sampling locations and determining the appropriate number of samples.

Study area-

For the experiment selected two location were chosen to analyze water treatment using phytoremediation technique. One of these sites is Chandlai Lake situated near Jaipur. The Chandlai Lake is located at 27.04’04 north latitude and 75.8306 east longitude in Jaipur. The rough estimate of lake is around 1.5 k.m. length and 1 k.m. in width. Water samples were collected from different pont across the lake for through analysis.

- In first season for an experiment, choose near the road side 27.0415 N latitude and 75.8325 E longitude.
- Then second was chosen near village 27.0380 N latitude and 75.8290 E longitude.
- And last was near railway track 27.0350 N latitude and 75.8310 E longitude.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

(The picture given in this page of Chandlai Lake was clicked in 2022)

2. Second water samples were collected from Barkheda pond of another site that is near Chandlai Lake around 6 k.m. far from it. The Barkheda pond located around 26.9004 N latitude and 75.7352 E longitude.

- In first season for the experiment chosen road side for sample collection.
- In second season for the experiment choose the area near the historic monuments for collection of sample.
- In third season the last sample was collected near the government school.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

(Fig. - 2 was clicked in 2022 of Barkheda pond and Fig. – 3 was taken from google map)

The sample collection-
Water samples were collected from various depths over three seasons to provide a comprehensive analysis of water quality of lake and pond. During the first season, samples were taken from a depth of 10 cm from pond and lake. In second season, water samples were collected from the surface of water. In the third season, the sampling depth was increased to 20 cm. from the surface of water from pond and lake. These samples of water from various depths provided valuable data's for analysis of the water physiochemical parameters.

Sample analysis-
The water analysis was conducted based on physiochemical and biological parameters. Observation of water from Chandlai Lake revealed that water was pale yellow in color, with unpleasant odor and contains some thread like substances in water. The Barkheda pond water samples were cleared and some algae like substances were present in water of pond. Physical characteristics of water can be decided by PH, Total Dissolved Solids (TDS), Total Suspened Solids (TSS), Temperature and chemical parameters Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Nitrogen, Leads and heavy metals.

Experiment set up-
The water quality assessment necessitates a unique experimental setup wherein four tubs having capacity of 35 liters of water and dimension of 50x49x31 cm were used. Moreover the cylindrical tubs with dimension of 38x38x57 cm. These tubs were labeled as A, B, C and D. Tub A and B contained water from Chandali Lake and Barkheda Pond respectively and serve as control groups. Tub C and D filled with Chandlai Lake and Barkheda pond water.

Nelumbo nucifera –
Lotus plant in month of June, 2022 were collected from village pond near chaksu. The pre-sterilized containers were used for harvesting the plants which were thoroughly rinsed using tap water to remove the dust and insects. The plants were thereafter placed in pots with one third of soil and two third of water, for duration of two weeks, ensuring adaptation to sunlight. Post the acclimation the plants were transferred into the experimental tubs setup. The damaged parts of lotus were carefully removed. The plants on the basis of uniform size were selected with 60 leaves in each plant. Post the washing the stems and roots were carefully inspected to avoid any fungal and bacterial infection. The Tubs with lotus plant were filled with soil until the roots were carefully covered. The tubs on the basis of designated name were either filled with water from Chandlai Lake and Barkheda Pond 5 liters of water along with 25 liters of tap water. The water of Pond and Lake immensely mixed and the lotus was planted alongwith the leaves which were floated on the surface on the water. The temperature of the water recorded at 10 am was approximately 27 degreeC. The experiment ensured sunlight for 9 hours and darkness for 15 hours on the daily basis. Testing duration- all the physiochemical test of water were conducted on the set up day of experiment, followed by additional testing at 7days interval on days 7, 14, 21.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

(Fig- 3 Lotus was planted alongwith leaves floating on surface of water in the tub C)

Results and discussion-

Analysis of waste water quality –

Analysis of pond and lake water was done on zero days, 7days, 14days and 21days. The water sample was collected from tubs with the help of beaker at morning time at 9 o'clock. The collection of sample was started on initial days. The sample water was filtered through filter paper and then transferred in plastic sample bottle. These sample bottle were covered with the help of cloths so the phytoplanktons cannot interfere in the analysis of physiochemical water.

Physiochemical parameter-

Sample was transferred to the laboratory in dark condition below 27 degree temperature, then analysis the physiochemical parameters of water.

- Physical parameter

Temperature, Color, Odor, Taste, PH, Total Dissolved Solids

- Chemical parameter

Nitrate, Chloride, BOD, COD,

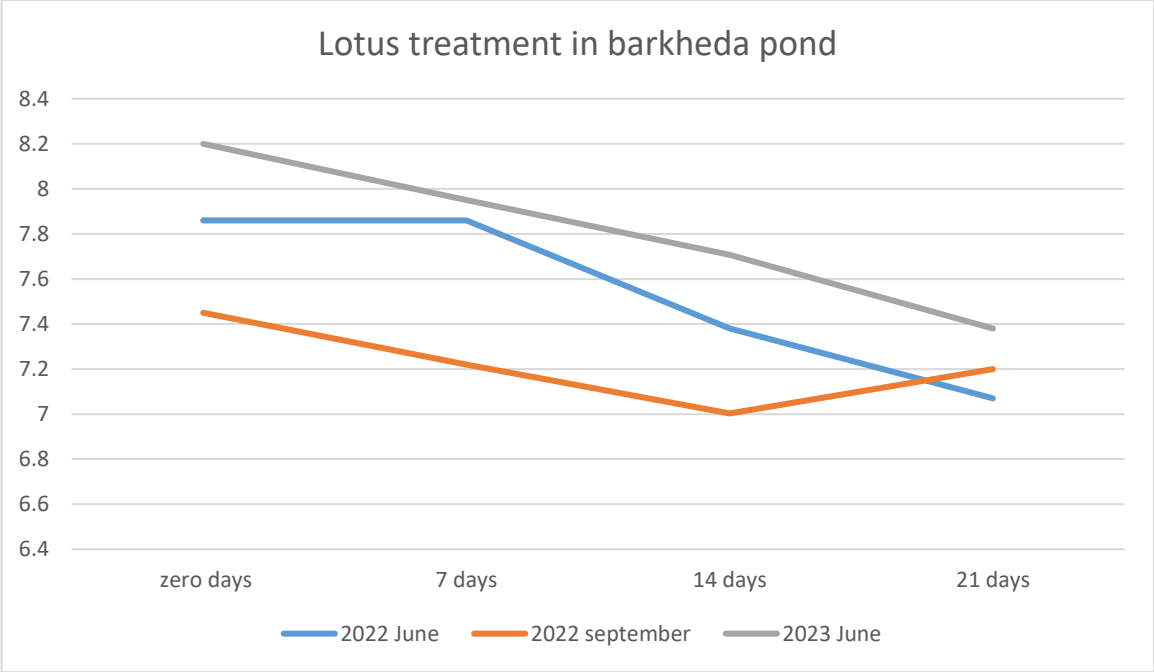
Physical and chemical parameters of water-

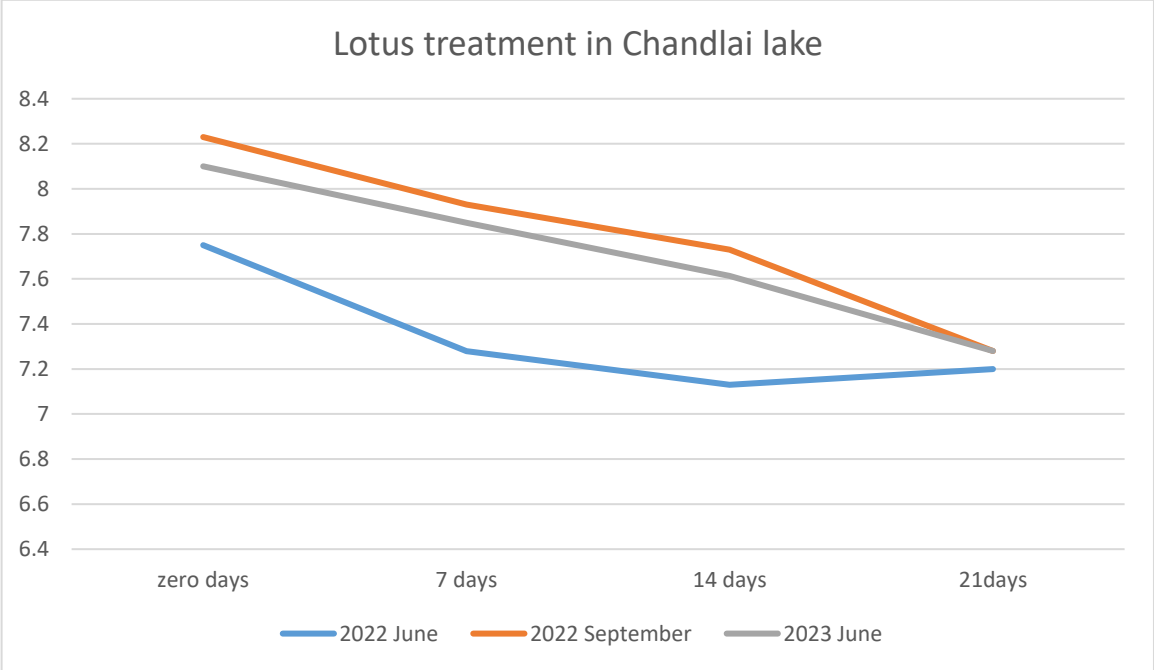
The parameters of water were measured by sample taken from lake and pond then they were compared with WHO standard and climate condition of environment can affect the pH, TDS, temperature of water (Sayom et al., 2023). The heavy metal also work as indicator of pollution like copper and nitrate (Lfie et al., 2021).

pH-

Nelumbo nucifera contain some microbes inside itself that release some gases which released in the sample that decrease the pH value , there is adjusting pH environment is created for nitrification for lotus which is 6-8 pH value (Akinbile et al ,.2012). There is increase value of pH by create OH ion in water for producing CO2 from bicarbonate (Azov, 1982). Raza Sindh, (2023) reported that pH also effect the absorption of heavy metal that is present in water. Till pH 4 the absorption capacity of lotus is less because the free H+ ion in water try to bind with heavy metal cation and after high pH value the absorption capacity is increase in solution(Mehta D et al ,. 2015).

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

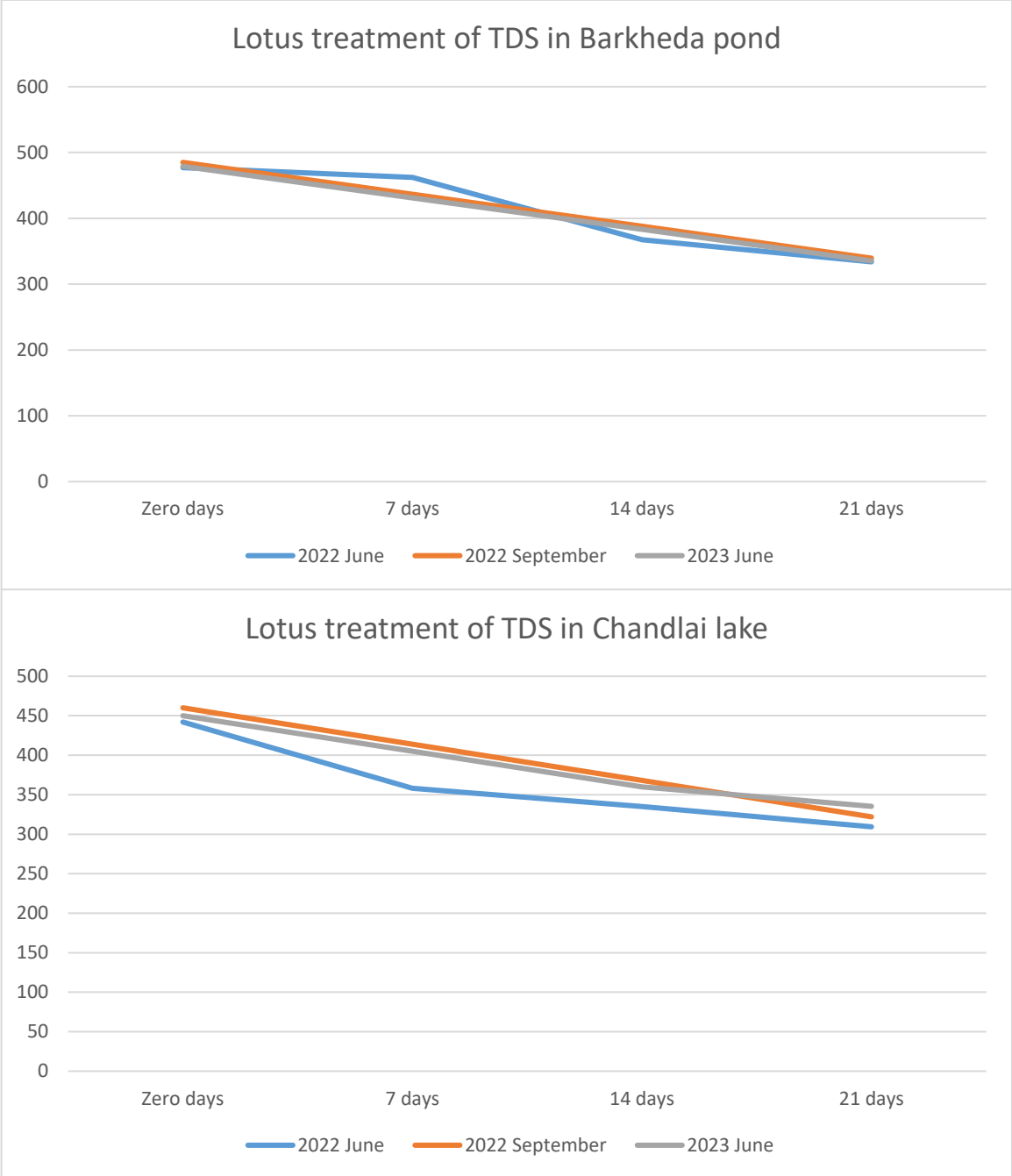




TDS-

Total dissolved solids in lake and pond found in organic and inorganic form which provide nutrition to water body in natural form. TDS means heavy metals are also present in it, which modified the organic and inorganic matter of lake and pond which is harmful for water body (Barman et al., 2018). TDS value of Barkheda pond was 477 ppm and TDS value of chandlai lake was 442 ppm. Absorbance of organic and inorganic material in water depend on surface area of roots of lotus by which the value of TDS continuously decrease till the roots are contact with water (Dyah puspito Rukmi,2014).

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

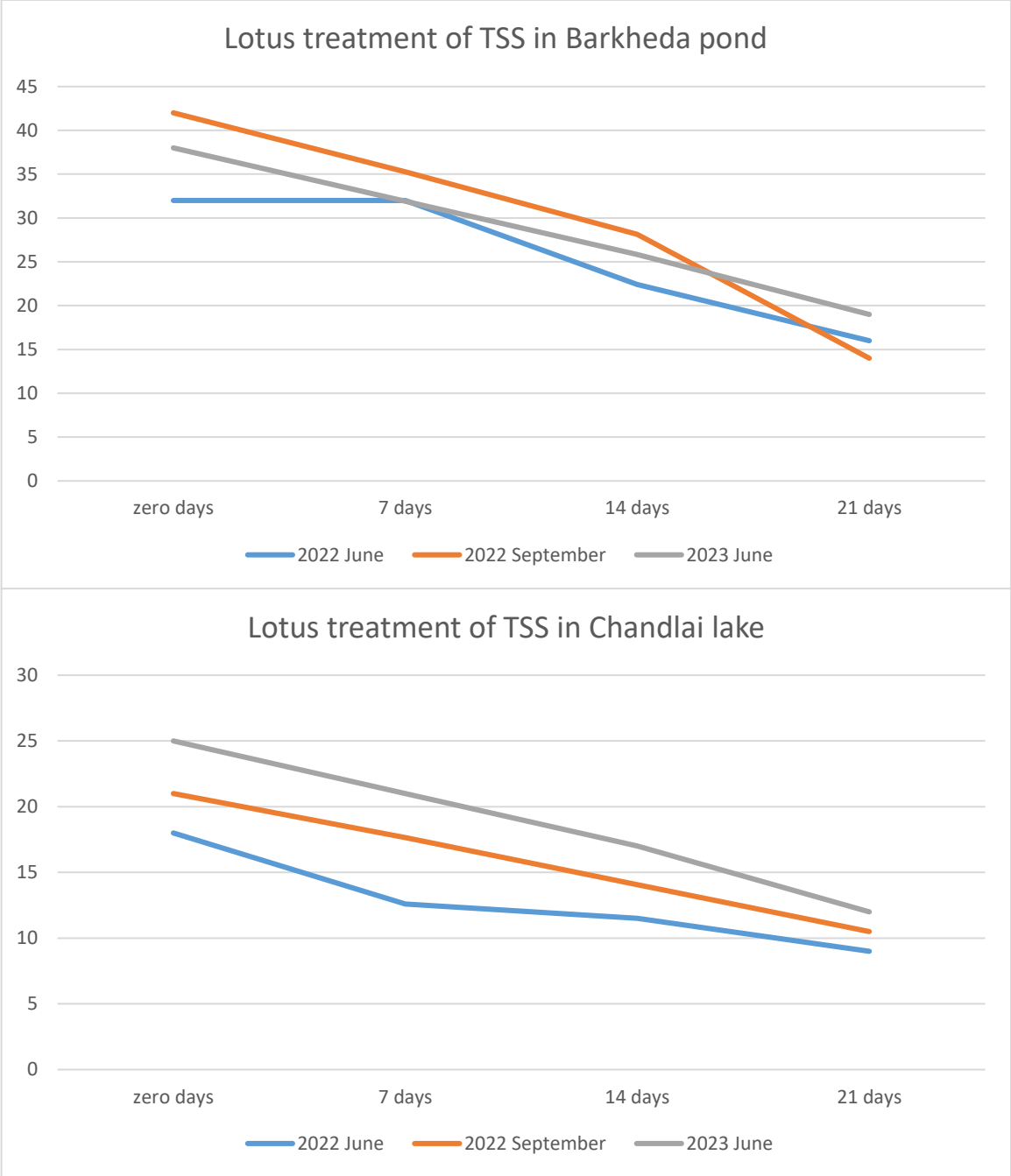


TSS-

Total suspended solids means organic matter inside the water body, which may be produce by algae or by discharge of organic matter in water by human by various sources, total suspended solid reduction was observed in lotus water, in winter there was more reduction observed in all three season experiment. Lotus have more roots and thick stem so it perform well, it have floating leaves on surface of water, which prevent it from sunlight and wind. The phytoplankton algae , cynobacteria and blue green algae present in water that produce nutrient by photosynthetic process, when there is blockage of sunlight by floating leaf there is reduction of TSS in water, when wind flow is less in water the water behaved as steady condition due to this the organic substance settle down in bottom there is reduction of TSS is observed in water, past study proved that in winter there is more reduction of TSS from water and lotus can covered more water surface, so it reduce more TSS from water (Hamidon et al,. 2020).

Uneaten material present in water which cause problem to aquatic organism and also increase TSS in water, by which enzyme activity increased in water which breakdown the uneaten matter in the water so there is reduction TSS is observed in water (Hainfellner et al., 2018).

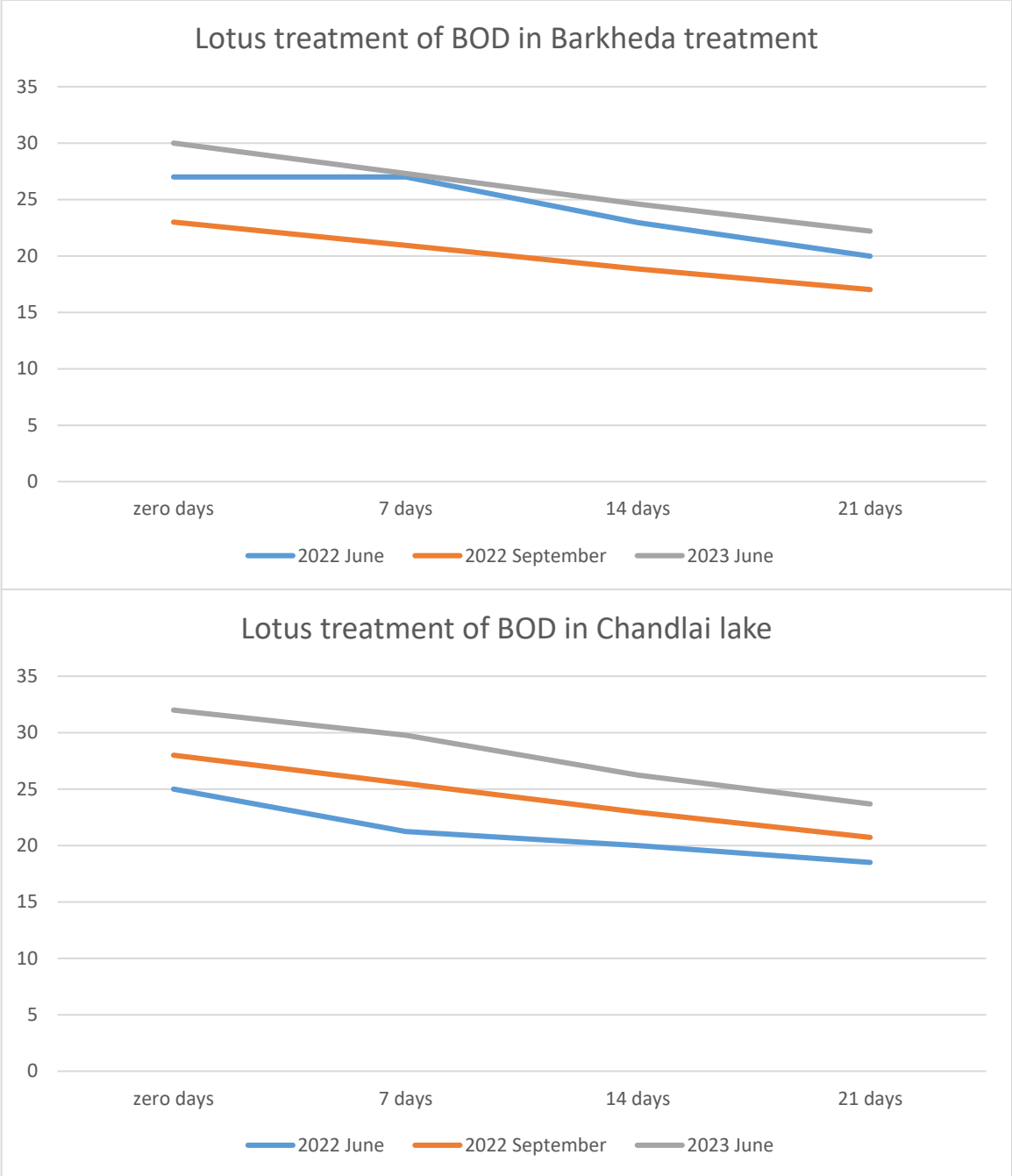
REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24



4 BOD

Biological oxygen demand means when more oxygen is utilize by organism or microorganism by organic or inorganic compounds are present in water which are degraded by enzyme so low demand of oxygen in water means it is non polluted. There is reduction of carbon dioxide in water by photosynthesis process and the end product of reaction is oxygen production, by which there is dissolved oxygen is produce and BOD reduction is observed (Brix 1989 ; Sinha et al 2014). In May month of the year there is more reduction of BOD is observed, in this period the lotus do flowering and so there is more reduction capability of lotus plant (Xing et al,. 2018). Lotus plant have less roots so microbial activity in lotus is more so the efficiency of removing BOD by lotus plant. (Jasrotia et al,. 2017).

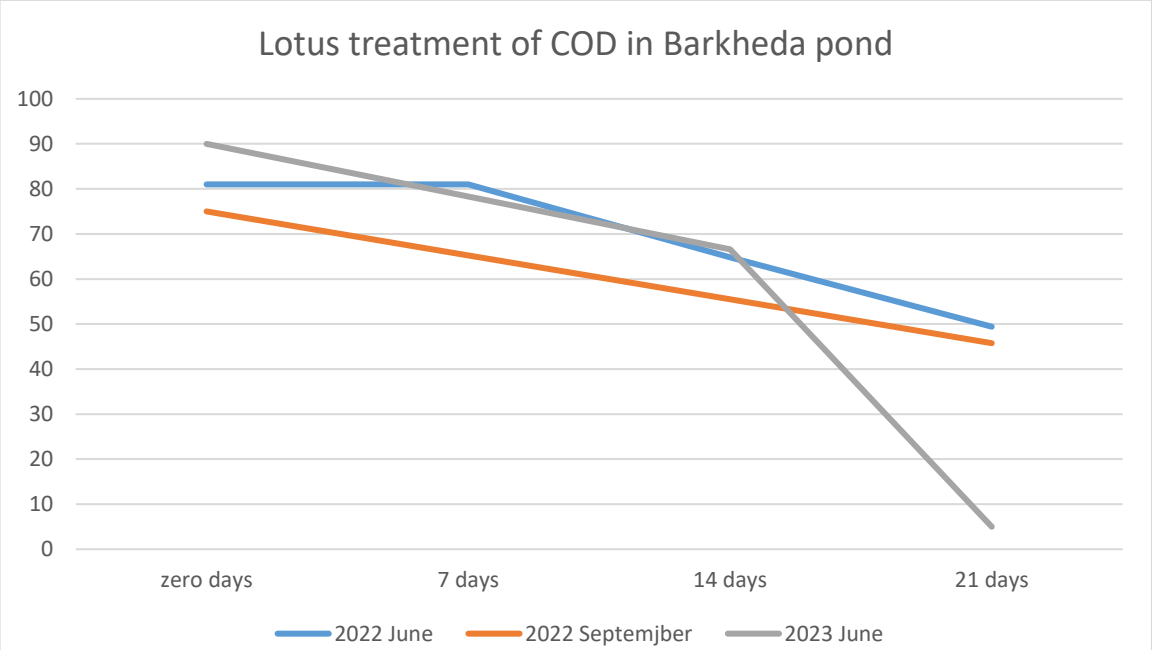
REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

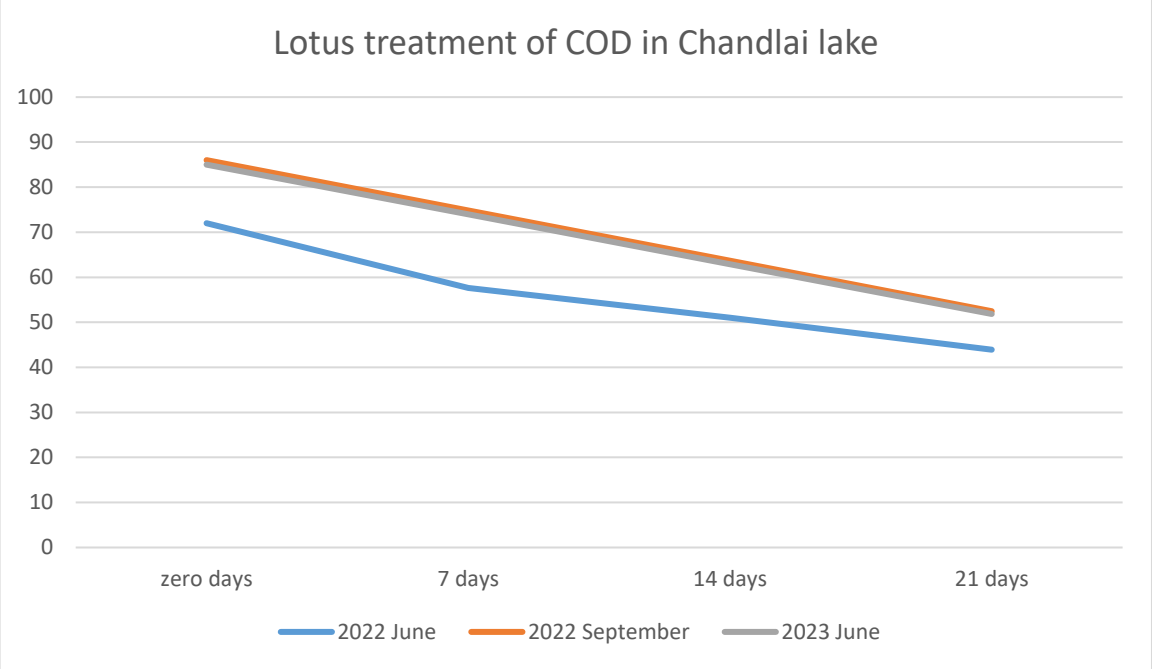


COD-

Chemical oxygen demand present in water, its mean the organic compounds that present in the water which use oxygen present in water to oxidized those organic compounds. Through the metabolism process, organic substance is utilized then CO2, H2O and energy are produced. The value of COD is decreased, and microorganism activity is observed due to gas exchange by which removal of COD value in water, this process is observed in Nelumbo nucifera, the reduction of COD is reached to standered value so it used in livestock drinking value (N.S. Abd Rasid et al,. 2019). Lotus leaf size is large so it cover more surface area and have more stomata on leaf surface so perform more photosynthesis, and it removal process observed after 7 days of COD (A. Jasroita et al,.2017). Accoring to N. S Abd rasid et al (2019) the lotus have capability to produce CO2 ,H2O and water from organic substance present in water by which the plant reduce COD from water.

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24



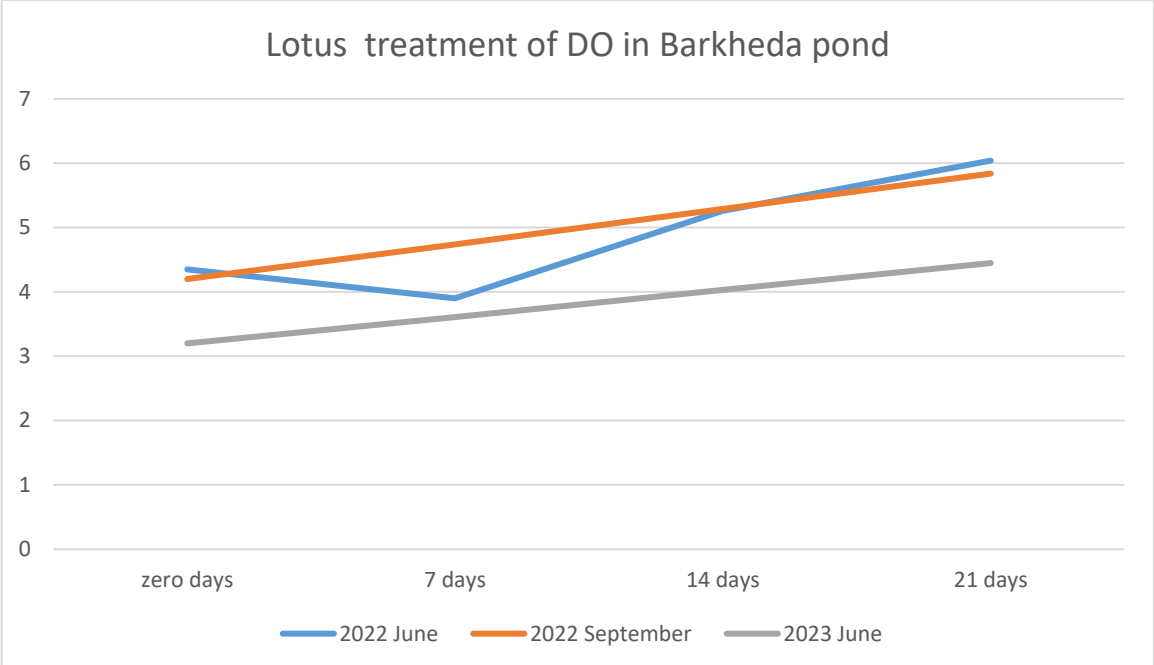


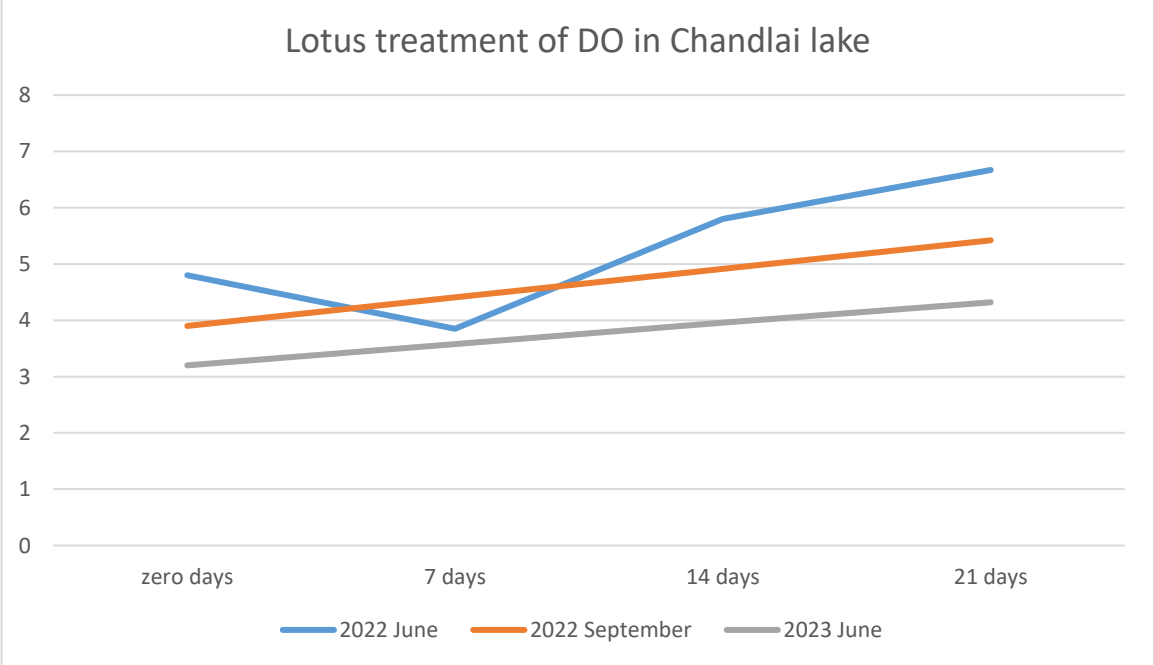
DO-

When the dissolved oxygen in water is decreased the aquatic animals in water do not get food and cannot grow properly in the water. This leads to increase the infection to the animals, dangerous for their health and produce vulnerable environment for aquatic animals (Dabrowski et al., 2018; Manahan, 2017). Dissolved oxygen is important parameter for measurement of quality of water. Higher value of oxygen in water describe the DO of water and provide the better environment for living organism. A study of Nuramidah Hamidon et al., (2020) Lotus plant also play vital role in treatment of grey water and it increase the dissolved oxygen in water which is significant parameter for quality of water. Lotus plant was cultivated in the tank and measured the parameters after few days of cultivation. Dissolved oxygen was increased by treatment of lotus in water. By presence of lotus in water the dissolved carbon dioxide reduced by the photosynthetic activities and oxygen is produced by lotus plant. By photosynthesis process the oxygen amount is increased in water and dissolved oxygen is also increase in the water. It also indicate that COD and BOD are also reduced by lotus plant. Lotus plant have bigger size of leaves, it have higher surface for stomata on leaves and it produce the oxygen by photosynthesis process. Lotus plant have fibrous massive roots system in water, which cause the higher dissolved oxygen in water. As the nitrogen and phosphorus in water is reduced by lotus plant this leads to increase the dissolved oxygen. Lotus plant

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

reduced the microbes in water which leads to decrease in consumption of dissolved oxygen in water (Xing Li, Xiaoqing Xu, and Mangmang Gou, 2018).



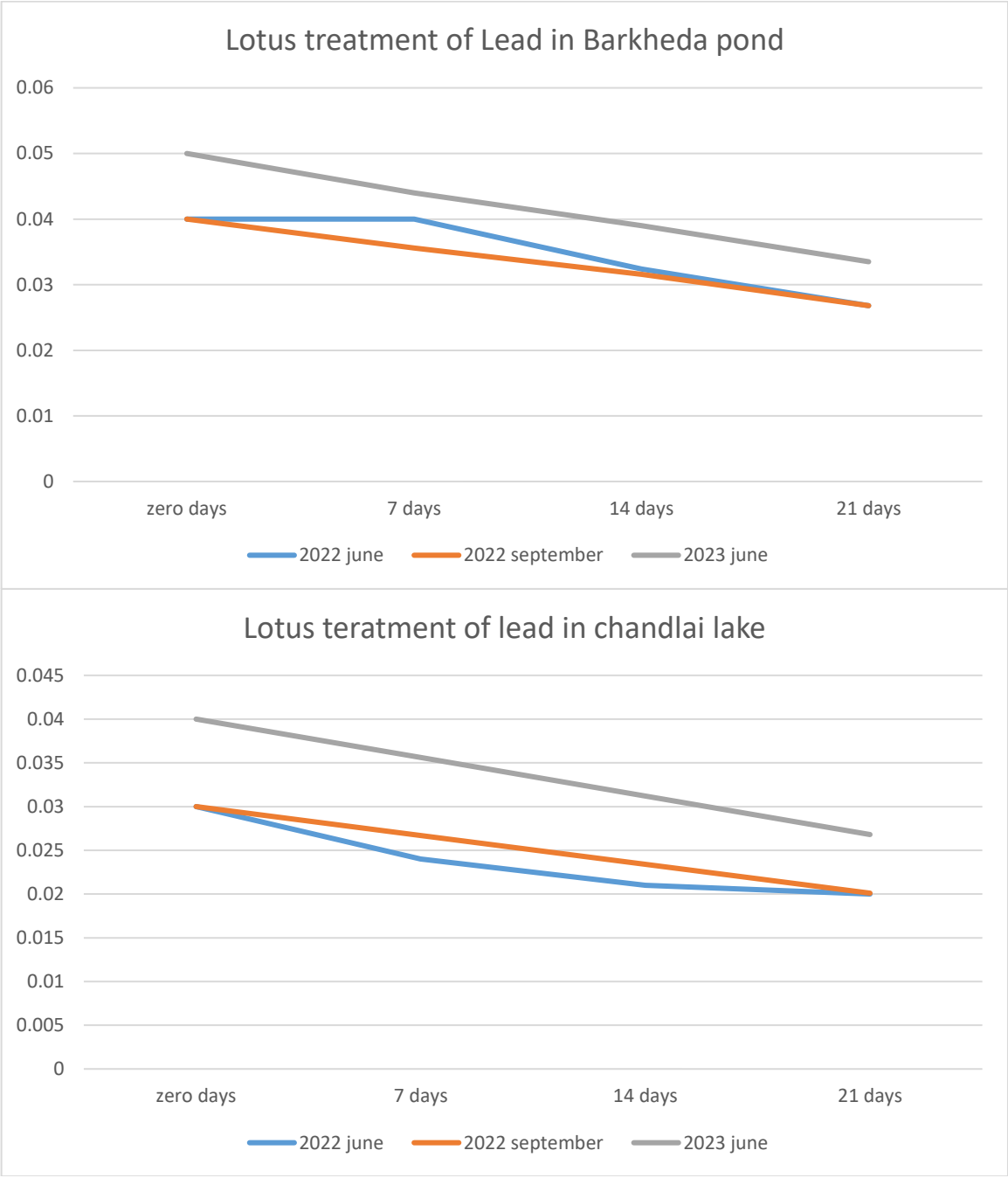


Lead-

Lead show its effect on health of aquatic animals and also effect on density of their population, also show effect on physiochemical cycle on aquatic organism (Croteau and Luoma 2011). Lotus show great result in reduction of lead from water which vary according to initial concentration and environment condition. Gupta, D.K. et al. (2014) told that lead in contaminated water which is taken by the plant which can disturbed the photosynthesis, growth of the plant and the enzymes of the plant which create a toxic environment for the plant so lotus take the lead from the water and transport to the tissue of the plant and various enzymes also play major role in reduction of the lead from the water. Phytoremediation is cheap process by cost to reduce the lead from water by using aquatic plants (Salt. D.E. et al., 1998.). Li et al. (2023) told in research lotus plants roots allowed to leave some chemical which take lead from the surrounding soil and some chemical activity done by citric acid and malic acid in the lotus roots which modified to lead ions and then it is transferred to the tissue of the lotus where that is accumulated. Ion transport of lead ion to the lotus plant leaf by epidermis of the stem by the process of passive diffusion which transport the lead ion from water to the upper part of the leaf of lotus plant

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

(Wang et al., 2022). According to the Zhang et al. (2024) lead is absorbed by the lotus from contaminated water, and modification of morphology in leaf of stomata and trichomes which Pb enter in the plant, some enzymes also play major role in the in reduction of lead from water like glutathione S transferases, peroxidase and ABC transporter which transfer the lead into the vacuole of the cell. Chen et al. (2023) told that there is modification of stem, roots and leaf of the plant which provide the surface for the absorption of the lead from the water, then the accumulation of lead in to the tissue of the plant.

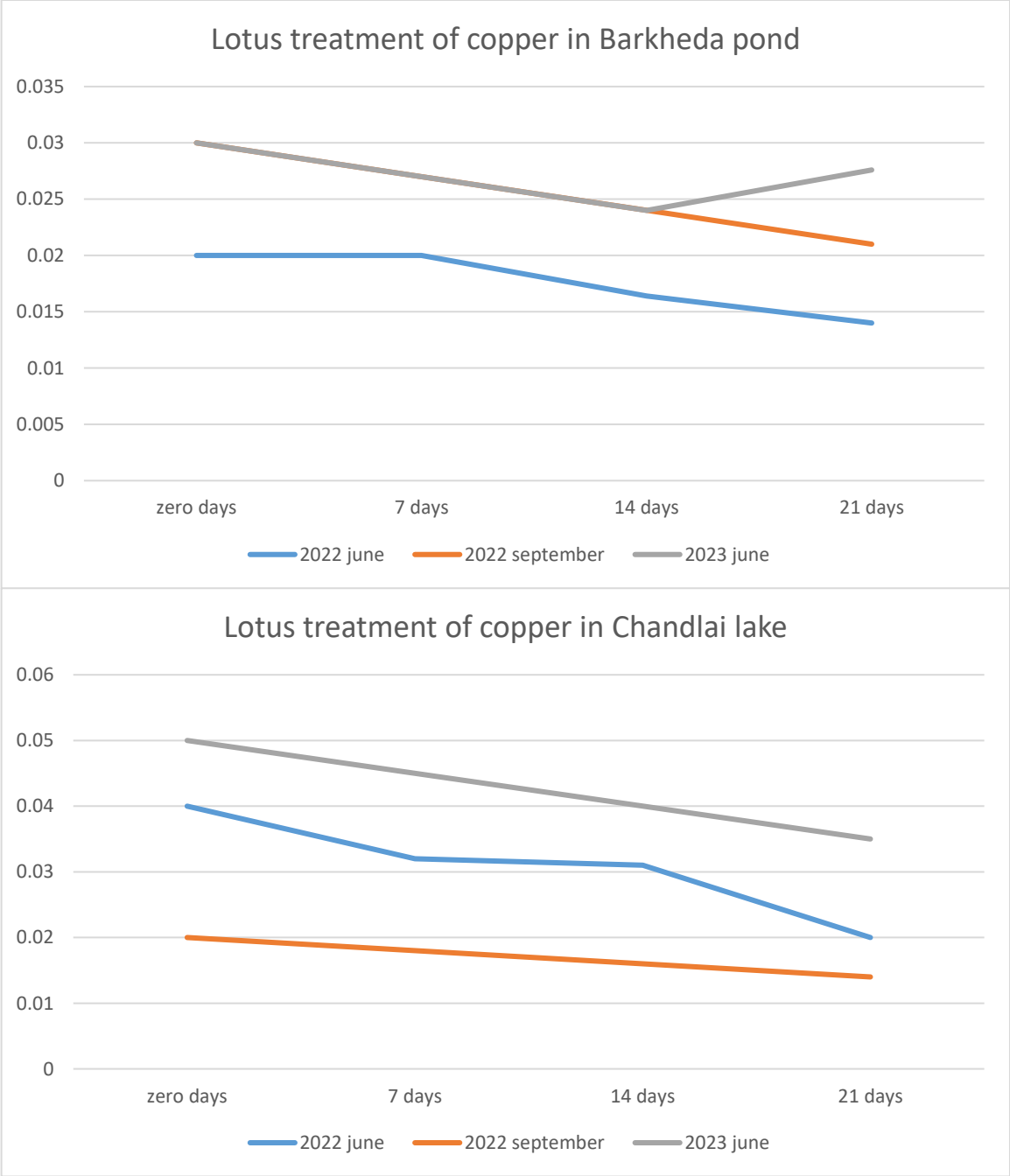


Copper-

Excessive amount of heavy metal in marine environment is harmful for ecosystem, and it show adverse effect on marine ecosystem of copper (Langston and W.J. 1990). There is reduction of copper in contaminated water is observed by lotus remediation. The reduction of copper is vary according to pH ,temperature and climate condition so in different season there is variation is observed in reduction value of copper. Phytoremediation of copper from the contaminated water, lotus plants absorb the copper ion from water then the transport of metal ion from roots to stem then accumulated into the tissue, there is factor which help in absorb physiological, biochemical and molecular process involved (Wang et al,. 2023). There is modification in stem, roots and stomata of plant which includes morphological adaptation according to stress of copper

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

ion in the water, and changes in physiological mechanism and molecular changes observed in plant by which copper ion taken by lotus plant and reduction of copper is observed in contaminated water (Zhang et al,. 2022). According to the Liu. Et al. (2021) there is relationship between lotus and bacteria of roots which help in reduction of copper from contaminated water, microbes of root which help in uptake of copper ion by roots and accumulation in tissue. The gene of lotus plant involve in detoxification of copper in water, there adaptation of molecular process for detoxification of copper ion which reduce the level of copper (Chen et al,. 2020). The reduction of copper from contaminated water is depend on physiochemical factor of climate like pH, temperature, heavy metals and there is optimal environment should be there for reduction of copper ion by lotus plant (Lin et al,. 2016).

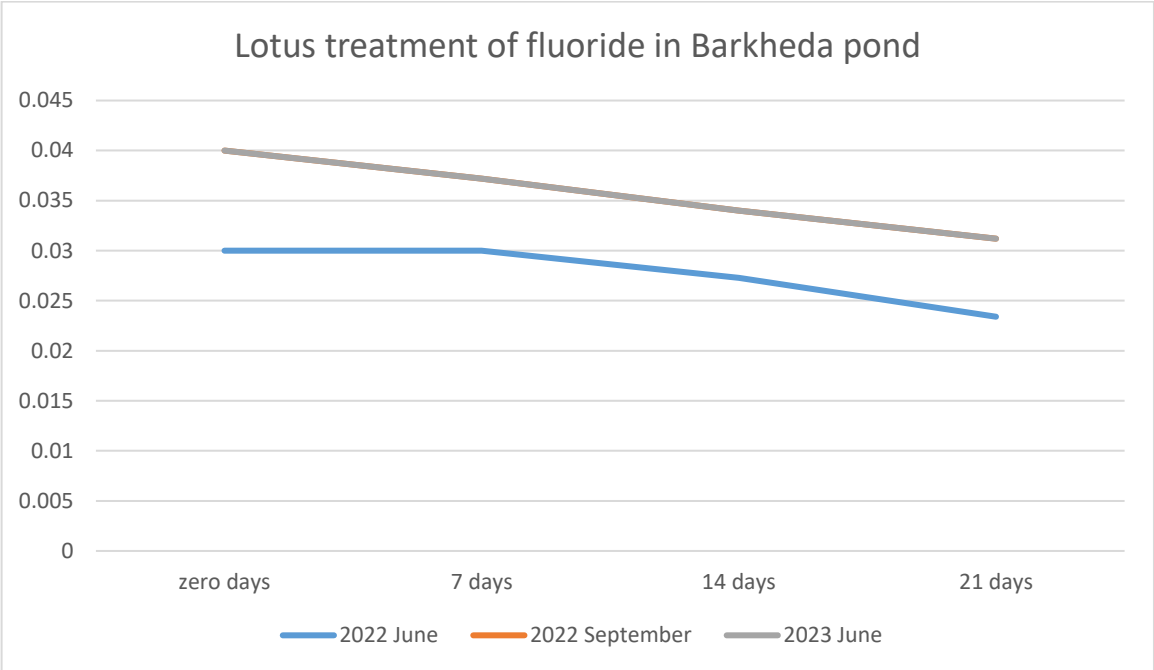


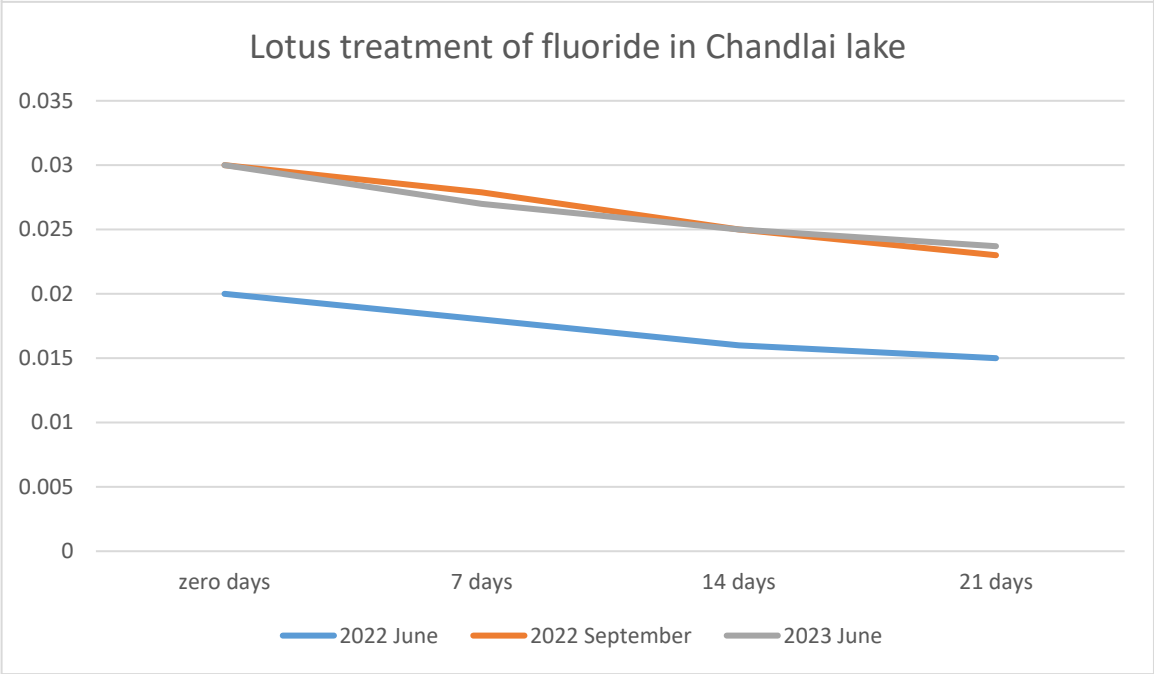
Fluoride-

Fluoride present in water is harmful for aquatic ecosystem and it can enter in skeleton of fishes and disturb the enzymatic activity of the livings (Julio A. Camargo .2003). Reduction of fluoride from water is depend on pH and temperature. According to Greenwood and Earnshaw (1984) fluorine is found in two state organic and inorganic form and inorganic form is present more than organic. It is most electronegative in the periodic table. Wang et al,. (2017) the roots of lotus took the fluoride from water and accumulation of fluoride inside the plant microbes help in filtration and degradation of

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24

fluoride take place inside the plant. By the whole process there is reduction is observed in water. Lotus not only reduce the fluoride from water but also reduce from surrounding soil and lotus plant have capability to reduce the fluoride (Chen et al,. 2020).

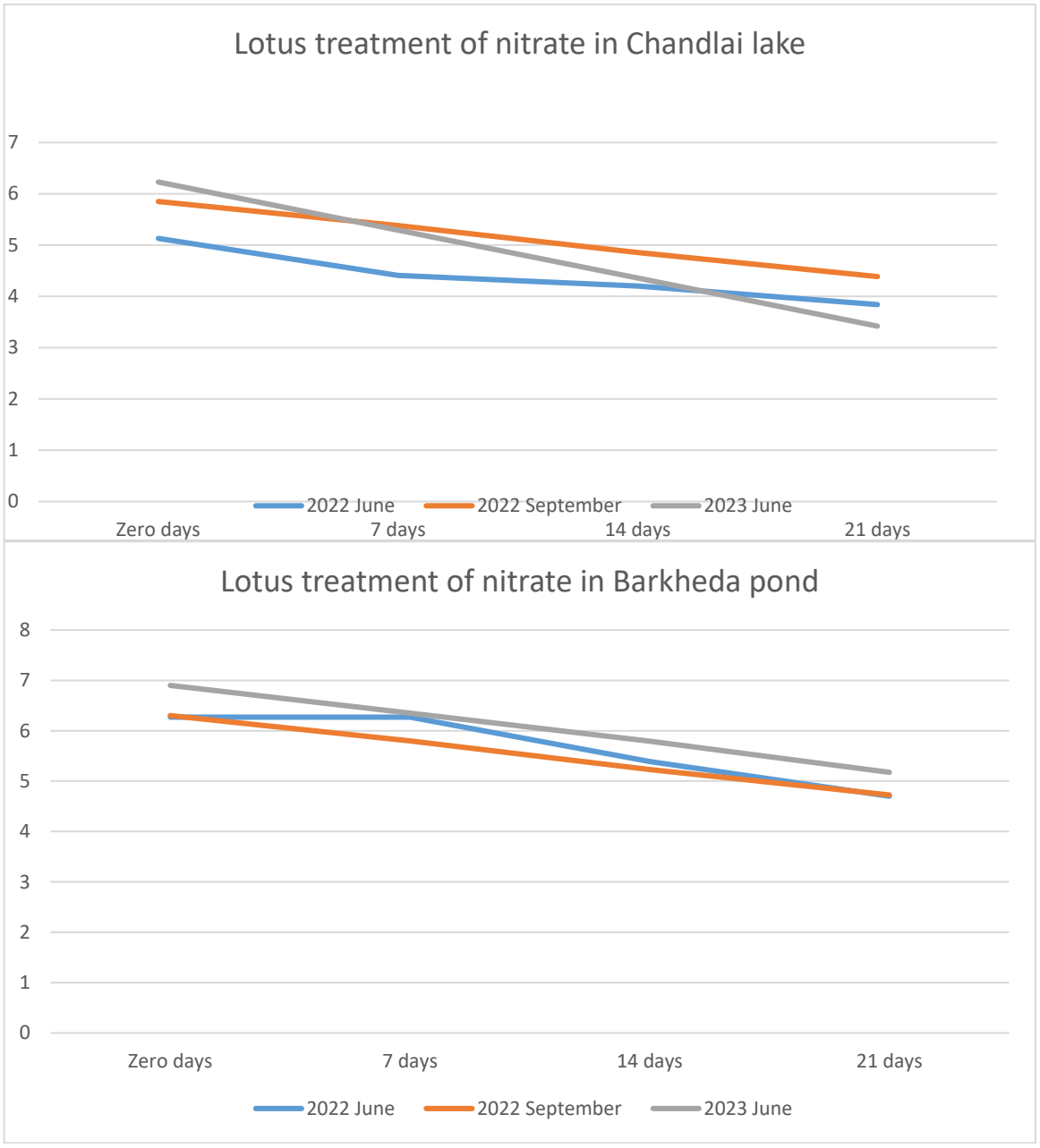




Nitrate-

Plants of water show great removal efficiency of nitrogen which access the bacteria in water for nitrification and denitrification by which the removal of nitrogen in observed in water, but as the plant die they release the nitrogen in water which reduce the removal efficiency of water (Thongchai Kanabkaew and Udomphon Puetpaiboon, 2004). Lotus show less amount of microbial activity in water so reduction process is less in lotus plant, aquatic plant not only absorbed dissolved nitrogen from water but also transport sufficient amount of oxygen to plant for gas supply, when plant is exposed to sunlight and then it show microbial activity which result the reduction of nitrogen from water (N. S. Abd Rasida et al,. 2019). October month of the year show highest reduction of nitrogen from the water, but in September month it show lower reduction in water, in October great reduction due to absorption from the roots of the lotus (Lee et al., 2006).

REDVET - Revista electrónica de Veterinaria - ISSN 1695-7504
Vol 25, No. 1 (2024)
http://www.veterinaria.org
Article Received:27/07/2024 Revised:20/08/2024 Accepted:14/09/24



Conclusion-

. In the lotus treatment of water slight reduction of pH about 12% in value in both pond and lake.

. The TDS reduced by lotus plant treatment by 30% but in resreach of Hamidon N. et al. (2020) its reduction efficiency of TDS higher than 60.88%, TSS was reduced 50% but in previous study it vary with environment Jiang and Xinyaun, (1998), BOD was reduced to 27% in study of S. Jasrotia, A. Kansal, and A. Mehra, (2017) is observed reductrion 94.74% of sample after 14 days, Another study of N. S. Abd Rasid et al. (2019) Bod reduction rate was 97.1 % in water. COD value is observed 39% of reduction in pre monsoon and post monsoon season water of lake and pond. In study of S. Jasrotia, A. Kansal, and A. Mehra (2017) observed that the reduction rate was better till 7 days after 7 days its reduction efficiency of COD by lotus is reduced. In study of Naim M. et al. (2019) COD reduction rate is 55 % after 30 days.

. The high value of DO means the quality of water is non-polluted. It means less contaminants are present in water.The DO was increased by lotus plant treatment by 39% in pre monsoon and post-monsoon season water of lake and pond. In previous study of Hamidon N. et L., (2020) it was 6.69 to 26.05 mg/l after 7 days of lotus treatment. After plantation of lotus in water the DO value increased to 39.31% in the recent study of Xing Li, Xiaoqing Xu and Mangmang Gou, (2018).

.The heavy metals in which lead was reduced to 33%, copper was reduced to 30%, the fluoride reduced to 22 % from water. The value of copper 85.82%, Lead 76.92% reduced in recent study of Arwa A. AL-Huqail, et al., (2022). Lotus can

reduce the 87%– 96% Copper in the 7 day incubation period studied by Mant, C., Costa, S., Williams, J. and Tambourgi, E.(2007). The reduction of fluoride from water by phytoremediation observed by Baunthiyal and Ranghar (2013).
. The nitrate value was reduced by 22% by treatment of lotus because The value of pH in water high is observed then denitrification and volatilisation occurred at different pH. The pH 7-7.6 of water then removal of nitrogen from water by the process of denitrification is observed at pH 7-7.6 of water The nitrate reduction from water by lotus 33% to 26% observed by Kato et al (2007) and another study of N. S. Abd Rasid et al. (2019) shows reduction of NO3 from water 33%. The reduction rate of pH high is observed research of Nuramidah Hamidon et al., (2020) and Xing Li, Xiaoqing Xu and Mangmang Gou (2018), M.F. Imron et al. (2019). The removal of nitrogen from water is also depend on depth of water, mainly at 3 centimetre of depth denitrification is observed (Körner and Vermaat, 1998).

References-

1. Abd Rasid, N. S., & Hashim, A. (2019). 'Phytoremediation of COD and BOD using aquatic plants'. 'Water Research', 148, 432-439. doi:10.1016/j.watres.2018.11.021.
2. Akinbile, C. O., & Yusoff, M. S. (2012). 'Assessing water hyacinth (Eichhornia crassipes) and lettuce (Pistia stratiotes) effectiveness in aquaculture wastewater treatment'. 'International Journal of Phytoremediation', 14(3), 201-211. doi:10.1080/15226514.2011.619236.
3. Azov, Y. (1982). 'Effect of pH on inorganic carbon uptake in algal photosynthesis'. 'Water Research', 16(1), 53-57. doi:10.1016/0043-1354(82)90116-5.
4. Barman, M., & Ghosh, D. (2018). 'Impact of total dissolved solids on water bodies: A review of organic and inorganic forms'. 'Hydrobiologia', 823, 45-56. doi:10.1007/s10750-017-3517-0.
5. Brix, H. (1989). 'Biological oxygen demand and lotus plants'. 'Aquatic Botany', 34(1-2), 155-168. doi:10.1016/0304-3770(89)90035-6.
6. Camargo, J. A. (2003). 'Fluoride toxicity to aquatic organisms'. 'Chemosphere', 50(3), 251-264. doi:10.1016/S0045-6535(02)00585-0.
7. Chen, Y., & Liu, P. (2023). 'Phytoremediation of lead from water using lotus plant modifications'. 'Environmental Science: Processes & Impacts', 25, 1321-1329. doi:10.1039/ d3em00256c.
8. Croteau, M. N., & Luoma, S. N. (2011). 'Lead toxicity in aquatic organisms'. 'Aquatic Toxicology', 104(3-4), 157-173. doi:10.1016/j.aquatox.2011.05.010.
9. Dyah Puspito Rukmi, D., & Kurniawan, R. (2014). 'The effect of water hyacinth (Eichhornia crassipes) and lotus (Nelumbo nucifera) on total dissolved solids in wastewater treatment'. 'Procedia Environmental Sciences', **20**, 395-402. doi:10.1016/j.proenv.2014.03.048.
10. Elias, G., et al. (2014). 'Rhizofiltration in the Remediation of Contaminated Waters'. 'International Journal of Phytoremediation', 16(5), 487-502. doi:10.1080/15226514.2013.810582.
11. Feng, X., et al. (2018). 'Use of Biological Techniques for Wastewater Treatment'. 'Applied Microbiology and Biotechnology', 102(5), 2119-2131. doi:10.1007/s00253-018-8780-7.
12. Garrido-Cardenas, J.A., et al. (2020). 'Advanced Oxidation Processes for the Removal of Antibiotics from Wastewater'. 'Journal of Environmental Management', 261, 110235. doi:10.1016/j.jenvman.2020.110235.
13. Gupta, D. K., & Nicoloso, F. T. (2014). 'Heavy metal stress and phytoremediation by aquatic plants'. 'Ecotoxicology and Environmental Safety', '105', 177-183. doi:10.1016/ j.ecoenv.2014.04.032
14. . 14. Hamidon, N., Noor, A., & Hamidon, N. A. (2020). 'Phytoremediation of suspended solids using lotus and duckweed'. 'International Journal of Phytoremediation', 2 (1), 77-85. doi:10.1080/15226514.2019.1615772.
15. 15.Hainfellner, E., & Rahmat, S. (2018). 'Biodegradation of organic waste and reduction of TSS in water'. 'Journal of Environmental Quality', 47, 86-92. doi:10.2134/jeq2018.02.0098
16. Jasrotia, A., & Kansal, M. (2017). 'Efficiency of lotus and duckweed in treating wastewater: Comparative study'. Environmental Science and Pollution Research, 24(3), 2456-2465. doi:10.1007/s11356-016-7989-9.
17. Jain, A.K., et al. (2003). 'Effects of Industrial Pollution on Rivers and Water Bodies in Rajasthan'. 'Indian Journal of Environmental Protection', 23(7), 754-762.
18. Khellaf, N., & Zerdaoui, M. (2009). 'Accumulation of Zinc and Nickel by *Water Hyacinth (*Eichhornia crassipes*)'. 'Journal of Hazardous Materials', 157(1), 363-368. doi:10.1016/ j.jhazmat.2008.10.010.
19. Kumar, P.B., et al. (1995). 'Phytoextraction: The Use of Plants to Remove Heavy Metals from Soils'. 'Environmental Science and Technology', 29(5), 1232-1238. doi:10.1021/es00005a014.
20. Langston, W. J. (1990). 'Toxic effects of metals in aquatic environments'. 'Marine Environmental Research', 30, 1-40. doi:10.1016/0141-1136(90)90002-4.
21. Lee, J., & Yang, J. (2006). 'Nitrogen reduction in ponds with lotus plants**. *Hydrobiologia', 573, 103-113. doi:10.1007/s10750-006-0274-1.
22. Liu, H., & Wang, Y. (2021). 'Microbial interaction with lotus roots in reducing copper contamination'. 'Applied Microbiology and Biotechnology', 105(3), 1045-1056. doi:10.1007/ s00253-020-11146-w.
23. Mehta, D., & Gaur, J. P. (2015). 'Use of algae for removing heavy metal ions from wastewater: Progress and prospects'. 'Critical Reviews in Biotechnology', 35(4), 435-454. doi:10.3109/07388551.2014.900179.

24. Mohanty, S., et al. (2005b).Phytoremediation of Heavy Metals Using Native Plant Species'. 'Journal of Environmental Quality', 34(4), 1239-1246. doi:10.2134/jeq2004.0216.
25. N. S. Abd Rasid, F., & Hashim, A. (2019). 'Phytoremediation of COD and BOD using aquatic plants'. 'Water Research', 148, 432-439. doi:10.1016/j.watres.2018.11.021.
26. Okunowo, W.O., & Ogunkanmi, L.A. (2010). 'Aquatic Plants for Phytoremediation of Contaminants from Wastewater'. 'Journal of Environmental Science and Health', 45(5), 521-528. doi:10.1080/03601231003719594.
27. Raskin, I. (2000). 'Plant-Based Technologies for Removal of Metals from Water: Phytoremediation of Contaminated Waters'. 'Environmental Science and Technology', 34(15), 303-308. doi:10.1021/es980420q.
28. Saha, P., et al. (2015). 'Duckweed Phytoremediation of Heavy Metals from Contaminated Water'. 'Ecological Engineering', 81, 47-52. doi:10.1016/j.ecoleng.2015.04.008.
29. Salt, D. E., & Krämer, U. (1998). 'Mechanisms of metal accumulation in plants'. 'Phytoremediation of Toxic Metals', 12, 25-43. doi:10.1007/978-1-4615-5332-7_2.
30. Shakibaie, M., et al. (2008). 'Toxic Effects of Heavy Metals on Environment'. 'Journal of Environmental Biology', 29(4), 683-688.
31. Singh, D., Tiwari, A., & Gupta, R. (2012). 'Bioremediation of Contaminants from Water Using Microbes'. 'Water Resources Management', 26(9), pp.
32. Singh, J. S., & Reddy, M. S. (2003). 'Phytoremediation of Organic and Inorganic Contaminants'. 'Environmental Science and Pollution Research', 10(4), 223-229. doi:10.1065/ espr2003.04.149
33. Subramanian, K., & Nair, V. (2010). 'Toxicity of Heavy Metals on Aquatic Plants: A Review'. 'Journal of Environmental Quality', 39(6), 1951-1958. doi:10.2134/jeq2010.0200.
34. Tiwari, R., & Shukla, K. (2021). 'Heavy Metal Contamination and its Impact on Aquatic Plants'. 'Journal of Water and Health', 19(2), 223-234. doi:10.2166/wh.2021.061.
35. Vasantha, S., & Kumar, P. (2019). 'Role of aquatic plants in wastewater treatment'. 'Environmental Monitoring and Assessment', 191(10), 651. doi:10.1007/s10661-019-7813-8.
36. Wang, X., & Zhang, Y. (2014). 'Phytoremediation of Wastewater Using Aquatic Plants'. 'International Journal of Environmental Science and Technology', 11(2), 657-666. doi:10.1007/ s13762-013-0293-8
37. Yadav, P., et al. (2019). 'Effectiveness of Lotus in Reducing Water Pollution'. 'Journal of Environmental Management', 243, 1-10. doi:10.1016/j.jenvman.2019.05.051.
38. Yoon, J., et al. (2006). 'Lead Phytoremediation by Lotus and Water Hyacinth'. 'Environmental Science and Technology', 40(14), 4571-4577. doi:10.1021/es0601954.
39. Zhang, X., & Liu, W. (2022). 'Phytoremediation of Nitrogen and Phosphorus using Aquatic Plants. 'Journal of Environmental Quality', 51(2), 245-256. doi:10.2134/jeq2021.08.0352