International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Wastewater management by using effective phytoremediator duckweed

YOGITA L. PADME *

Department of Environmental science, Dr. Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar, M.S. India.

International Journal of Science and Research Archive, 2024, 13(02), 2619–2622

Publication history: Received on 30October 2024; revised on 09 December 2024; accepted on 11 December 2024

Article DOI: https://doi.org/10.30574/ijsra.2024.13.2.2437

Abstract

Water pollution and the increasing discharge of untreated wastewater into natural water bodies are intensifying the pressure on aquatic environments. Sustainable and eco-friendly methods are essential for restoring water quality and mitigating pollution. One such approach is water phytoremediation, which involves the use of aquatic plants to remove pollutants from water bodies and ecosystems. This study explored the removal of contaminants from municipal wastewater using floating aquatic plants such as *Lemna minor*, which have proven highly effective for phytoremediation due to their low cost, high pollutant uptake capacity, minimal generation of chemical and biological sludge, ease of transport, adaptability to diverse climatic conditions, and rapid reproduction rates.

Notable findings from the research include reductions in chemical oxygen demand (COD) by 82.2%, biological oxygen demand (BOD) by 84.3%, phosphates by 63.8%, ammonium nitrogen by 75.4%, and nitrates by 79.1% for *Lemna minor*. Maximum plant growth occurred during the experiment at pH levels between 7 and 8. The study demonstrated that large-scale remediation could be effectively achieved using *Lemna minor* as a phytoremediation agent within 17 days. This method offers a cost-effective, efficient tertiary treatment for heavily polluted wastewater. Additionally, it can serve as an independent treatment solution when integrated with preliminary wastewater treatment systems in smaller communities.

Keywords: Phytoremediation; Lemna minor; Wastewater; Sustainable

1. Introduction

The global water crisis is one of the most critical challenges facing the world today. According to the 2014 report by the World Health Organization, it is projected that by 2025, more than half of the global population will experience water scarcity. The degradation of water quality due to pollution and environmental deterioration is a significant contributor to this scarcity. In June 2018, the National Institution for Transforming India (NITI Aayog) published the Composite Water Management Index report, highlighting that Delhi and 21 other cities in India were at risk of depleting their groundwater resources by 2020. The increasing strain on surface water sources is exacerbated by the inflow of untreated or partially treated wastewater into primary water streams.

Phytoremediation is an emerging technology categorized as a form of bioremediation that utilizes plants to remediate polluted environments. This method leverages the ability of plants to thrive in contaminated water while facilitating the removal of pollutants from the environment (Ting et.al.2018).

This is also an aesthetically appealing method that is cost-effective and preserves the environment *in-situ*. Duckweeds are invasive, floating aquatic macrophytes with ecological and economic impacts wherever their colonies are established. Duckweeds are small, simply structured aquatic plants or macrophytes that float on the surface of still

*Corresponding authorYOGITA L.PADME

water bodies. The vegetative body of duckweed, known as a frond, is a thallus-like structure only a few cells thick, representing a fusion of leaves and stems and exemplifying the extreme reduction of a vascular plant. Duckweeds belong to the family Lemnaceae, comprising 37 species distributed across 5 genera (Ziegler and Appenroth, 2016).

In recent years, there has been growing concern about the negative environmental impacts of traditional wastewater treatment systems, such as greenhouse gas emissions and sludge generation. This has spurred increased interest in alternative wastewater treatment technologies that are more sustainable and environmentally friendly. Aquatic plants have been identified as one such alternative technology, offering a sustainable and cost-effective solution for wastewater treatment.

Duckweed, in particular, has demonstrated significant potential due to its rapid growth and high efficiency in removing nutrients from wastewater. If its effectiveness in nutrient removal and biomass production is confirmed, duckweed could supplement or even replace traditional wastewater treatment systems. This would reduce the costs and environmental impacts associated with wastewater treatment while providing a valuable source of biomass for energy production (Mahima and Bindu, 2020).

2. Material and methods

2.1. Sample and material collection

Waste water samples were collected from different sites, Sewage from Begampura nearby government Hospital of ChhatrapatiSambhajinagar. For the determination of physicochemical parameters such as pH, BOD, COD, Alkalinity, Total Hardness, TDS. Wastewater sample were transported to the laboratory and preserved by using preservative agent. The Duckweed (Lemna minor) which served as tool of phytoremediation was collected from fresh water body. The collected plants were acclimatized for one week to stabilize the plant. Wastewater samples were treated with plant by phytoremediation for 5days to 12 days. The pre analysis and post analysis was carried out to know the effectiveness of treatment. The physicochemical analysis was carried out by the standard methods as describe by APHA (1998), R. K. Trivedy and P.K. Goel (1984) as well as Kodarkar (2008).

The collected duckweeds were confirmed by species identification from the book of 'Flowering plants of Kerala: a checklist', Kerala forest research institute, Peechi. *Lemna minor* is from the family of Lemnaceae. Individual plants of *Lemna minor* consist of single, flat oval leaf, not more than ¼ inch long that floats on the surface of still-moving ponds or lakes. The inflorescence consists of two microscopic staminate flowers and one yinypistillate flower in a pouch-like sag, mostly unseen. They grow quickly and produce offshoots rapidly.

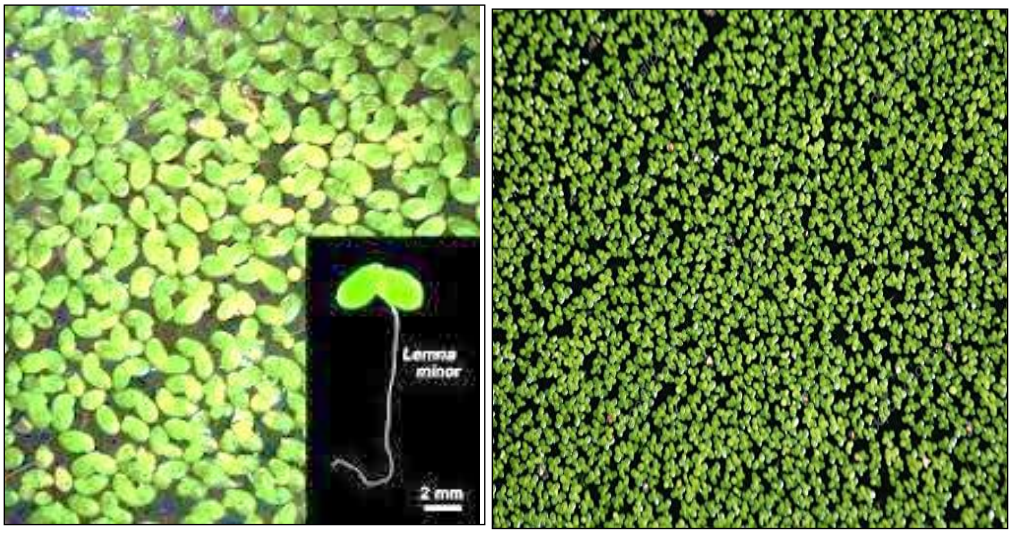

Figure 1 *Lemna minor* (common duckweed)

2.2. Experimental study

Following the identification, the duckweeds were washed with deionized water and made ready for use. Experiments were carried out at ambient temperature around 30°C. The system consist of a trays of 1440 cm2 surface area and an

effective volume of 5 liters. The key operational parameters investigate for their influence on COD, BOD, nitrate, ammonia nitrogen and phosphate removal efficiencies were hydraulic retention time, pH and biomass dosage. The samples were taken out at 7th, 16th and 25th day and filtered through Whatman filter No.1 for the chemical analysis to determine optimum results.

3. Results and discussion

Wastewater treatment using macrophytes have good popularity due to its efficient mechanism in bioremediation and is an eco-friendly approach. Duckweeds were considered as a promising macrophyte as they show rapid growth and proven history of remediating ponds and many wastewaters. In the present study, phytoremediation of Domestic wastewater was carried out using duckweeds, *Lemna minor.* the factors affecting the remediation process were set and the effect of such factors like pH, retention time and biomass dosage of the duckweed were assessed. The results conveyed that all the factors affect the process performance significantly for the *Lemna minor* duckweed.

Thus, this intensive study on *Lemna minor* species showed a considerable reduction in COD, BOD, phosphate, ammonia nitrogen and nitrate. The mechanism behind the removal of BOD and COD was phytodegradation and the nutrient uptake using roots and fronds of the duckweed by phytoextraction, nitrification and denitrification would be the reason behind the nitrate and ammonia nitrogen reduction. The phosphate removal mechanisms may be absorption and phytoextraction. While observing the percentage removal efficiencies of each parameter, it was very clear that, *L. minor* shows more dominant effect domestic wastewater treatment in the optimized condition. The percentage removal obtained using *L. minor* were 82.2%, 84.3%, 63.8%, 75.4% and 79.1% for COD, BOD, phosphate, ammonia nitrogen and nitrate respectively.

Table 1 Results of duckweed implemented wastewater at day 12 (under certain conditions)

Parameter	Initial value (mg/L)	Final value (mg/L)	Removal Efficiency (%)	Effluent Standards* (mg/L)
Nitrate	65.26	13.62	79.12	45
Ammonia nitrogen	20.73	5.10	75.37	5
Phosphate	16.53	5.97	63.83	4
BOD	303.45	47.79	84.25	30
COD	880	157.08	82.15	50

The result shows that, only nitrate met the EPA discharge limit. So, we cannot fully depend on phytoremediation when the pollutant concentration is high. Hence, *L. minor* could be used after primary and secondary treatment when the pollutant concentration is high and could give a maximum output in 17 days in an optimum pH of 7.3.

4. Conclusion

The present research work concludes that *Lemna minor* can perform well in municipal wastewater when compared to sewage and sea food processing plant wastewater treatment systems. Through this investigation, it could be concluded that the nutrient removal load in wastewater can be reduced through duck weed and thus eutrophication could be avoided. There by it is also possible to improve the quality of different wastewaters. The treated wastewater can be used for agriculture and aquaculture activities. The nutrients wasted through wastewaters could be used to produce *Lemna* biomass and the same could be used as feed for livestock or production of fuel.

Also, the local availability of the Lemna. minor makes it a low-cost solution to water treatment problems. Because of the high percentage removal, it could be suggested as a suitable solution for raw wastewater as a stand-alone treatment with preliminary facilities, for grit settling, in small villages.

References

[1] Bal Krishna KC, Changrak Polprasert.2008. An integrated Kinetic model for organic and nutrient removal by duckweed-based wastewater treatment (DUBWAT) system. Ecological Engineering 2008; 34:243-250.

[2] Center TD, Hill MP, Cordo H, Julien MH. Water hyacinth.2002. In: Van Driesche R.., Biological control of Invasive plants in the Eastern United States. USDA Forest Service publication FHTET, 2002, 41-64.

[3] Ekperusi, A. O., Sikoki, F. D., Nwachukwu, E.O. 2019. Application of Common Duckweed (Lemna minor) in Phytoremediation of Chemicals in the Environment: State and Future Perspective, Chemosphere, (2019), 223, 285-309.

[4] El-Shafai, S., El-Gohary, F., Nasr, F., Petervandersteen, N., &Gijzen, H. 2007. Nutrient recovery from domestic wastewater using a UASB-duckweed ponds system, Bioresource Technology, (2007), 98(4), 798–807.

[5] Gupta, C., and Prakash, D. 2013. Duckweed: an effective tool for phyto-remediation, Toxicological & Environmental Chemistry (2013), 95(8), 1256–1266.

[6] Kamyotra, J.S. and Bhardwaj, R.M. 2011. Municipal Wastewater Management in India, India infrastructure report (2011), 299- 311.

[7] Kumar, V. and Chopra, A. K. 2017. Phytoremediation potential of water caltrop (Trapa natans L.) using municipal wastewater of the activated sludge process-based municipal wastewater treatment plant, Environmental Technolog(2017), 39, 12–23.

[8] Kutschera, U., and Niklas, K. J. 2014. Darwin-Wallace Demons: survival of the fastest in populations of duckweeds and the evolutionary history of an enigmatic group of angiosperms, Plant Biology (2014), 17, 24–32.

[9] Lakshmi, K.S., Sailaja, V.H., Reddy, M.A. 2017. Phytoremediation - A Promising Technique in Waste Water Treatment, International Journal of Scientific Research and Management (IJSRM) (2017), 5(6), 5480-5489.

[10] Mahima A R, Bindu G.2020.Phytoremediation by Duckweed in Municipal wastewater treatment. International Journal of Creative Research Thoughts,8(9),301-305

[11] Mohedano, R. A., Costa, R. H. R., Tavares, F. A., & Belli Filho, P. 2012. High nutrient removal rate from swine wastes and protein biomass production by full-scale duckweed ponds. Bioresource Technology(2012), 112, 98–104.

[12] Muradov, N., Fidalgo, B., Gujar, A. C., and T-Raissi, A. 2010. Pyrolysis of fast-growing aquatic biomass – Lemna minor (duckweed): Characterization of pyrolysis products, Bioresource Technology, 101(21), 8424–8428.

[13] Myers, R. H., Montgomery, D. C., and Anderson-cook, C. M. 2009. Response Surface methodology- Process and product optimization using designed experiments, A John Wiley abd Sons (2009), 3, 14-135.

[14] Neveux, N., Magnusson, M., Mata, L., Whelan, A., Nys, D.R and Paul, N.A. 2016. The treatment of municipal wastewater by the macroalgaOedogoniumsp.,its potential for the production of bio-crude, Algal Research(2016), 13, 284-292.

[15] Ozengin, N., and Elmaci, A. 2007. Performance of Lemna minor L. on different types of wastewater treatment, Journal of Environmental Biology (April 2007), 28(2), 307-314.

[16] Priya, A., Avishek, K., and Pathak, G. 2011. Assessing the potentials of Lemna minor in the treatment of domestic wastewater at pilot scale, Environmental Monitoring and Assessment (2011), 184(7), 4301–4307.

[17] Ting, W.H.T., Tan, I.A.W., Salleh, S.F and Wahab, N.A. 2018. Application of water hyacinth (Eichhornia crassipes) for phytoremediation of ammoniacal nitrogen: A review, Journal of Water Process Engineering (2018), 22, 239-249.

[18] Ziegler, P., Sree, K. S., and Appenroth, K.-J. 2016. Duckweeds for water remediation and toxicity testing,Toxicological& Environmental Chemistry (2016), 98(10), 1127–1154.