Treatment of Domestic Wastewater by Aquatic Plants

[1]Jasmin Lad, [2]Dr. Arti Pamnani
[1]M. E Student, [2]Sr. Lecturer
[1]B V M Engineering College, [2]B & B Institute of Technology
Vallabh vidyanagar, India

Abstract: In wastewater engineering, one of the most sophisticated methods of wastewater treatment is the tertiary treatment and biological treatment. A large number of inputs in the form of capital investment and energy have been placed for few decades now for meeting up the wastewater treatment objectives. To compensate these costs, natural wastewater treatment technologies, particularly the application of aquatic plants for wastewater treatment have been considered for quite long. The ability of aquatic ecosystem, mainly the aquatic plants to carry out wastewater purification has been exploited and this forms one of the major principles for natural wastewater treatment technologies. This study, constitute of various underlying concepts and principles involved in the wastewater treatment using aquatic plants. The study also present the results obtained from the research study carried to investigate the treatment or removal efficiency of aquatic plants (water hyacinth and typha angustifolia) to remove pollutants from wastewater via constructed wetland technology.

Keywords- Phytoremediation, root zone technology, domestic wastewater treatment, macrophytes, aquatic plants, constructed wetlands.

I. INTRODUCTION

Water is a one of the precious natural resources of this planet and it is a basic need for survival of life. Quantity of portable water is slowly reducing and it becomes major problem in the world. Population growth, urbanization and industrialisation have lead to various types of environmental problems like land pollution, water pollution, air pollution and sound pollution. Major environmental pollution occurs due to the outflow of effluents from various domestic and industrial sources. The water of rivers, lakes and oceans is also being polluted on a large scale (Chopra et al. 2016). Recycle and reuse of water is extremely important. Treating wastewater is the way to overcome water shortage due to the water pollution problems. There are many treatments available for purifying the wastewater like primary treatment, secondary treatment and tertiary treatment. Some of the suitable wastewater treatment processes for domestic wastewater include biological treatment processes such as activated sludge, trickling filter, and rotating biological contractor systems. However, these treatment systems have high operation, investment costs, difficult to operate and maintain with stable removal efficiencies. These limitations can be overcome by the application of non-conventional eco-friendly approaches of wastewater treatment like Phytoremediation. It is economical and environment friendly (Brix et. al. 1989, Valipour et. al. 2011, Lakshmi et al. 2017, Kumar et al. 2015).

II. PHYTOREMEDIATION

Phytoremediation is a biological process which is used to eliminate pollutants from wastewater by using plants. Its combination of two Latin words plant and remedy, gave rise to the term phytoremediation. It is a clean, inexpensive and efficient technology. It is a non-invasive alternative technology for engineering based remediation methods. The term “Phyto-remediation Technique” includes the life interactions of bacteria, the roots of the wetland plants, soil, air, water and sun. This type of treatment is an engineered method of purifying waste water as it passes through artificially constructed wetland area. This treatment is most effective with constructed wetland technology. The constructed wetlands are low cost, simple, environmentally non-disruptive, low land requirements and eco-friendly technology for water purification (Yulinah et al. 2008)

The principle of phytoremediation process is to clean up contaminated water by growing aquatic plants which have a capacity to absorb pollutants. This technology had been used in industrial and domestic effluent and wastewater treatment in removing of nutrients, organic chemicals, pesticides, oils, explosives, heavy metals and sewage pollutants. Phytoremediation includes several processes like, phytoextraction, phytodegradation, phytofiltration, rhizofiltration, phytostabilization and phytovolatilization (Gupta et al. 2012, Lakshmi et al. 2017).

Phytoremediation technique is highly effective to treat different types of wastewater. Many different types of plants have been used variously in phytoremediation. Aquatic plants absorb elements through roots and shoots. Much interest in typha angustifolia, duckweeds, water hyacinth, water lettuce, and vetiver grass recently have indicated that the plants have potential for removal of a wide range of pollutants such as total suspended solids, dissolved solids, electrical conductivity, hardness, biochemical oxygen demand, chemical oxygen demand, nitrogen, phosphorus, heavy metals, and many other contaminants related to wastewater (Gupta et al. 2012).

2.1. Macrophytes and its role

The three types of macrophytes are emergent, free- floating and submerged which have been discussed above. Macrophytes play a major role in reed beds, influencing biological, chemical and physical treatment processes. Physical effects include: Filtration of suspended material, protection against erosion by reducing turbulence and flow velocities stabilization of sediments and providing the surface area for micro-organisms. Metabolic functions of macrophytes include nutrient uptake and O2 release from roots into the rhizosphere. Macrophytes have adapted to anaerobic conditions by developing internal air spaces which transport O2 to the root zone. These air spaces form an extensive system throughout the plant and can occupy 60% of the total tissue volume. Many research studies differs on the potential for macrophytes to release O2 from roots to the surrounding rhizosphere thus providing aerobic conditions for plant nitrification to occur. A study by concluded that internal O2 movement not only supplied to buried plant tissues but also leaked O2 into the rhizosphere. Macrophytes can also provide habitat for flora and fauna and increase aesthetic appeal (Guo et. al. 2003, Klomjek et. al. 2005, Demirezen et. al. 2014, Hamizah et al. 2015).

The primary motivation behind the development of phytoremediation technologies is the potential for low – cost remediation. It is the use of green plant based system to remediate contaminated soils, sediments and water. Such plants are known as pollution mitigators. The key factor for the success of remediation process depends on characteristics to mine water, geo climatics conditions, type of amendment used and selection of plant species (Rezania et al. 2015). The most important factor in successful implementation of phytoremediation is the selection of appropriate plant which should have high uptake of both organic and inorganic pollutants, grow well in polluted environments and easily controlled (Lema et al. 2014). In this study four aquatic plants (Typha angustifolia and Eichhornia crassipes) are used for treatment of domestic wastewater.

III. MATERIALS AND METHODS

3.1. Collection of domestic wastewater and plants

Domestic wastewater was collected from sewage treatment plant and then analysed in the experimental setup. Wastewater collected from inlet chamber. The parameters involved are pH, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Water hyacinth and typha angustifolia were randomly collected from vadtal lake, Anand. These macrophytes were selected on the basis of local availability.

3.2. Experimental setup and operation:

Figure 1: Continuous flow reactor

Figure 2: Batch reactor

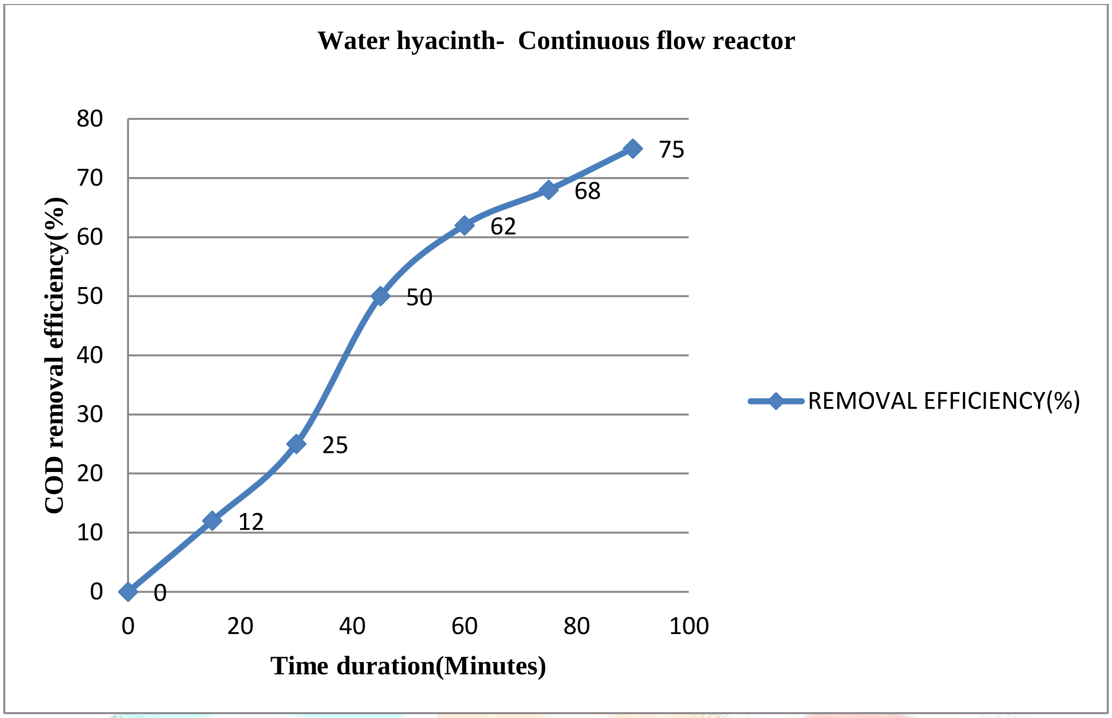
Experiments were performed in plastic tubs of 56.5 * 39.5 * 16.5 cm. The experimental system was bucket-reactor based and consisted of 2 plastic buckets and a 12 L tank for wastewater storage. The plastic bucket reactors had a capacity of 20 litres. Flow rate is 1.5 L/hr. For continuous flow reactor, water samples were taken every 15 min from each tub for water quality analysis. For batch reactor, water samples were taken at every 1 hour. pH, DO, COD, BOD were analysed as per standard methods. (APHA). Quantity of plants is 50% of area.

IV. RESULTS AND DISCUSSION

Table 1: Removal efficiency of plants

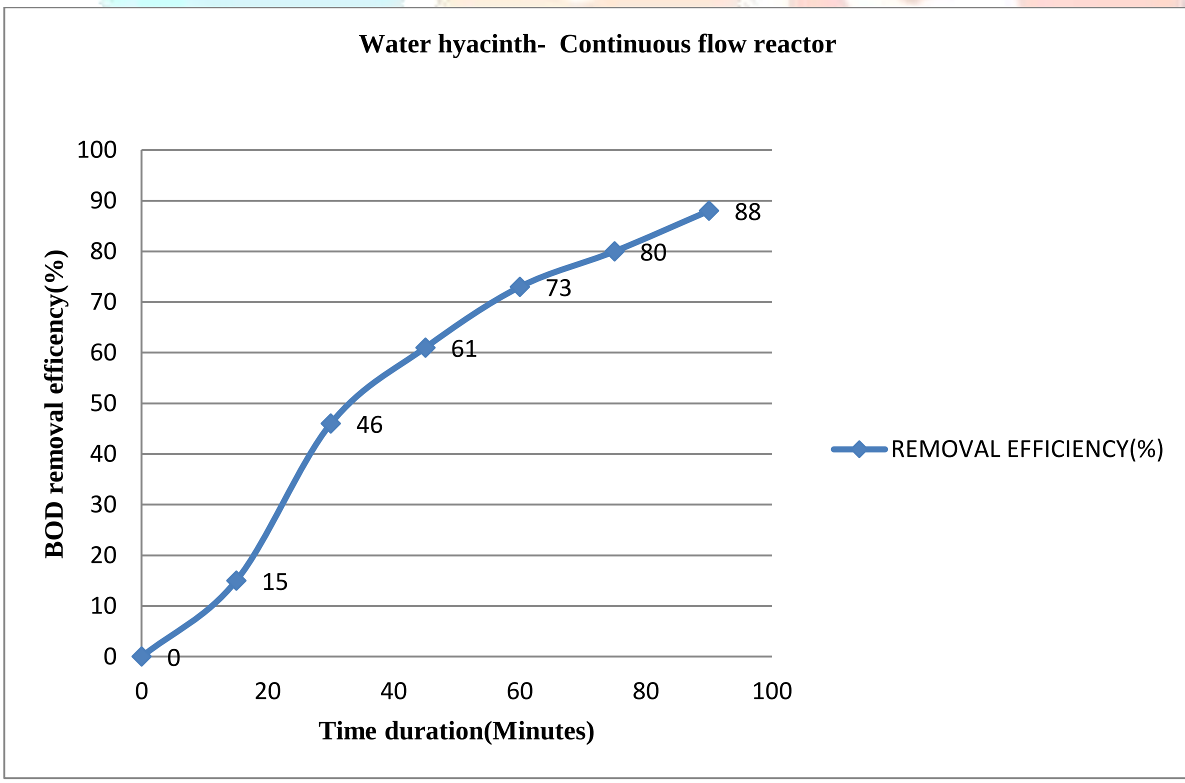
Type of Reactor	Removal efficiency (%)			
	Water hyacinth		Typha angustifolia	
	COD	BOD	COD	BOD
Continuous flow reactor	75	88	80	89
Batch reactor	68	84	60	82

Table 1 shows the removal efficiency of both plants in continuous flow reactor and batch reactor. For water hyacinth, COD and BOD removal efficiency is very from 68 to 75% and 84 to 88% respectively. And for typha angustifolia COD and BOD removal efficiency is very from 60 to 80% and 82 to 89% respectively.



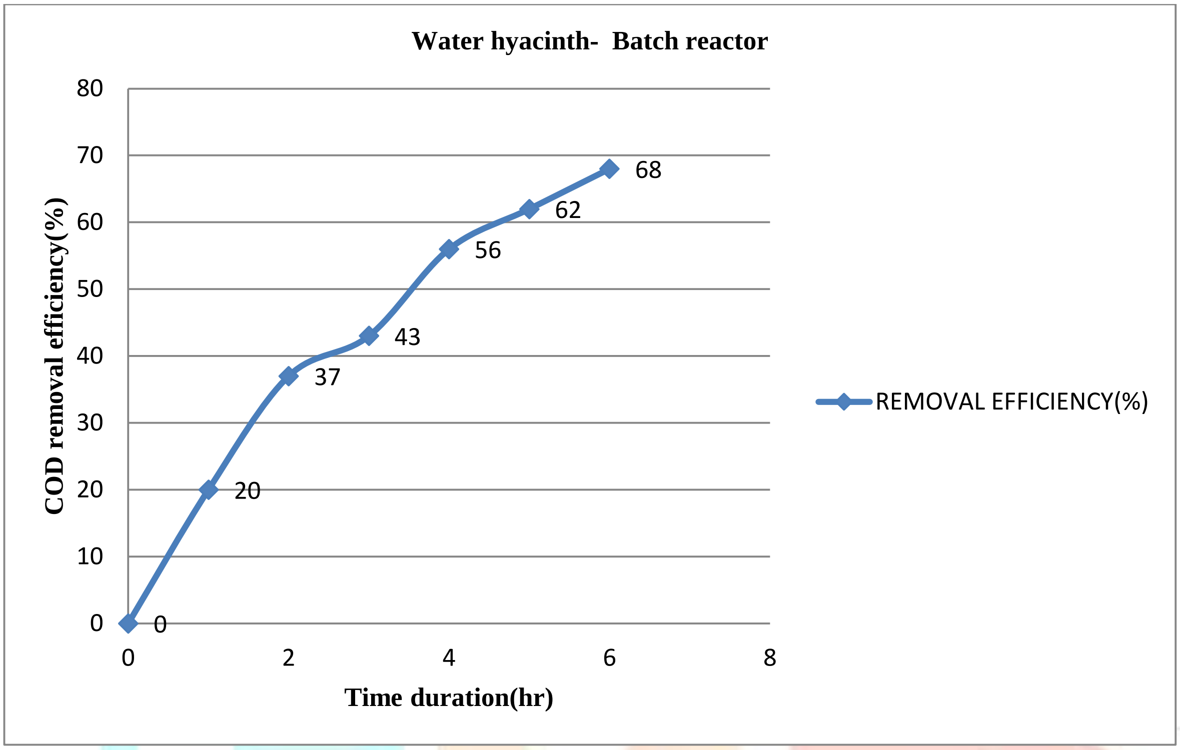
Graph 1: COD removal efficiency of water hyacinth

Graph 1 shows COD removal efficiency in continuous flow reactor. Maximum removal efficiency is 75%. And in time duration of 30 to 45 minutes, higher removal efficiency is gained.



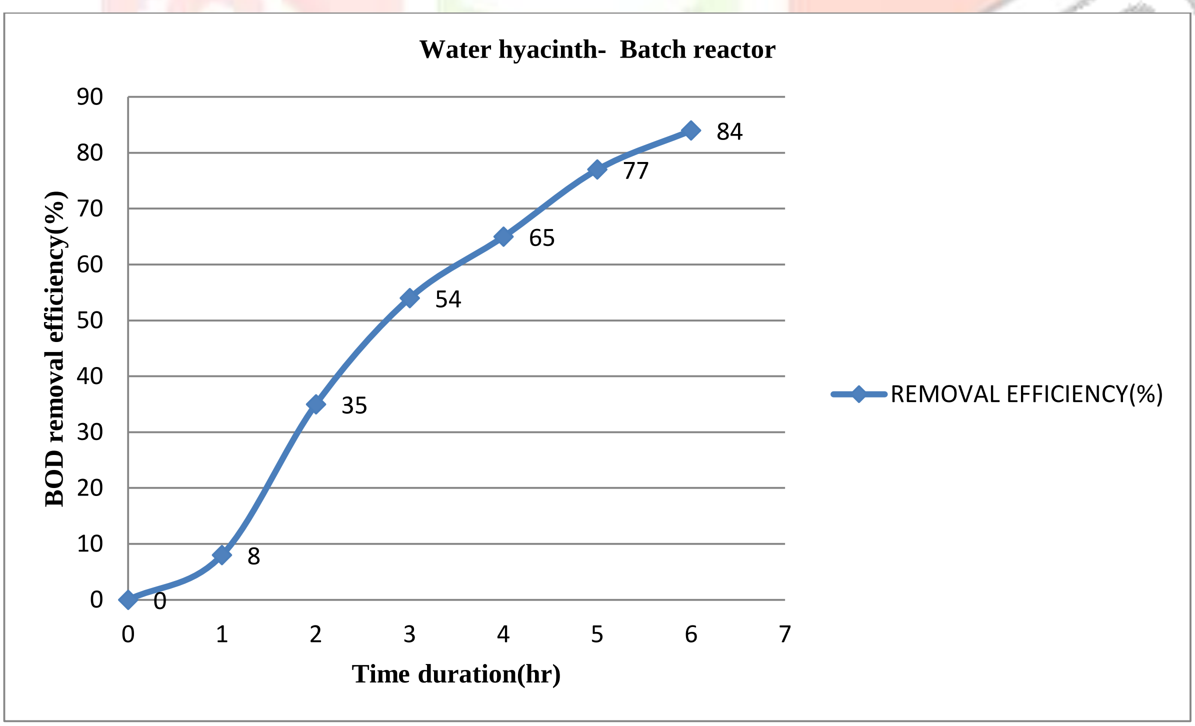
Graph 2: BOD removal efficiency of water hyacinth

Graph 2 shows BOD removal efficiency in continuous flow reactor. Maximum removal efficiency is 88%. And in time duration of 15 to 30 minutes, higher removal efficiency is gained.



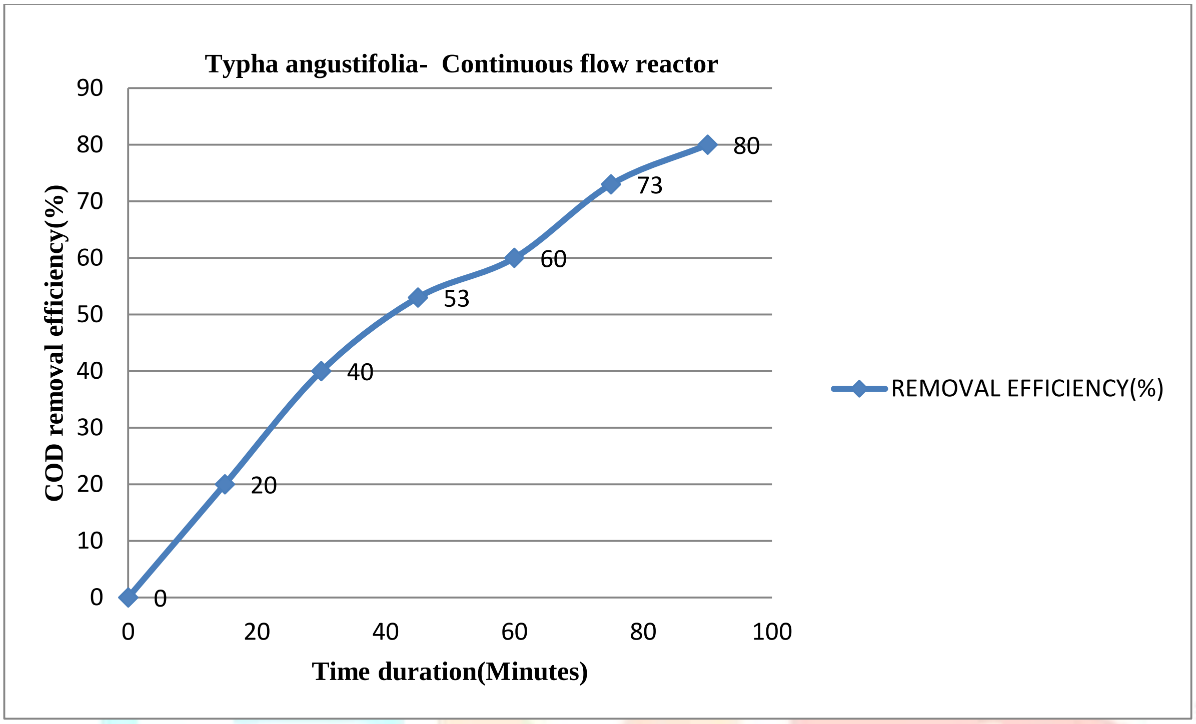
Graph 3: COD removal efficiency of water hyacinth

Graph 3 shows COD removal efficiency in batch reactor. Maximum removal efficiency is 68%. And in time duration of 2 to 3 hours, higher removal efficiency is gained.



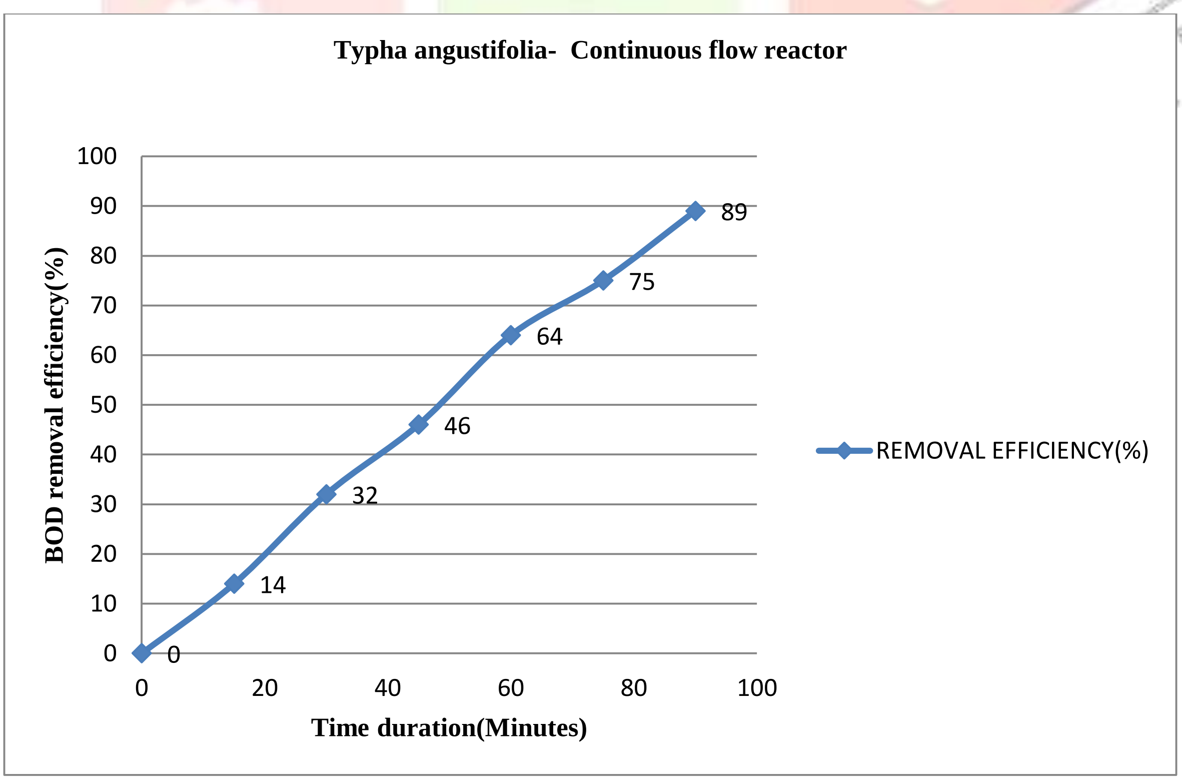
Graph 4: BOD removal of water hyacinth

Graph 1 shows BOD removal efficiency in batch reactor. Maximum removal efficiency is 84%. And in time duration of 2 to 3 hours, higher removal efficiency is gained.



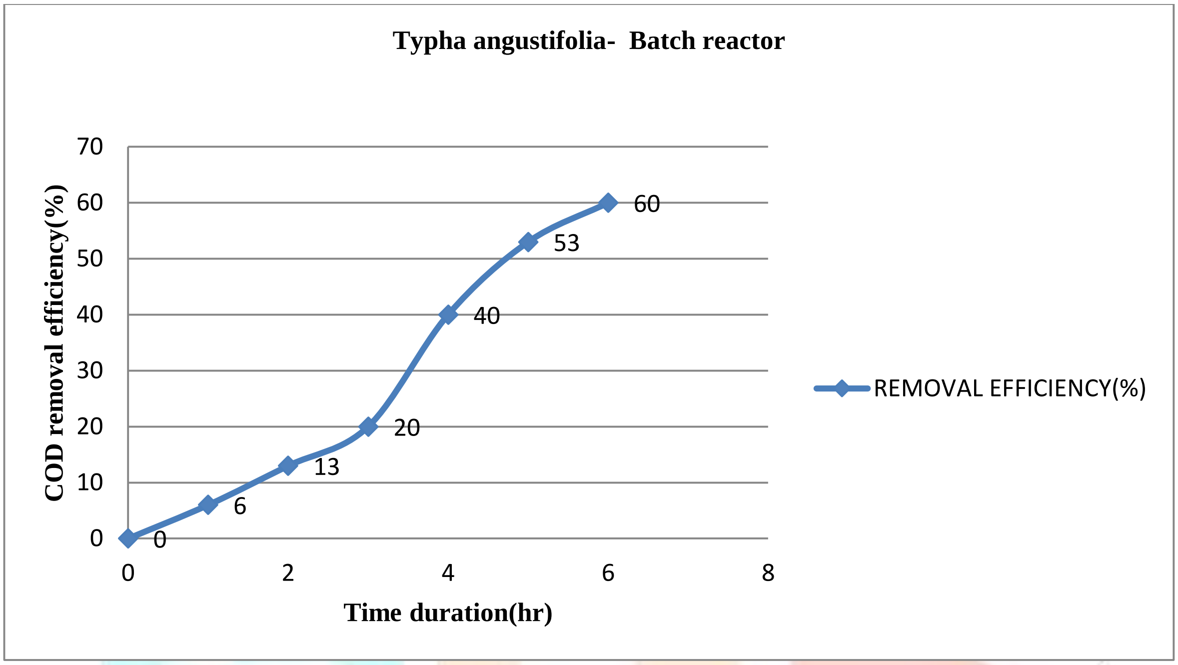
Graph 5: COD removal efficiency of typha angustifolia

Graph 1 shows COD removal efficiency in continuous flow reactor. Maximum removal efficiency is 80%. And in time duration of 15 to 30 minutes, higher removal efficiency is gained.



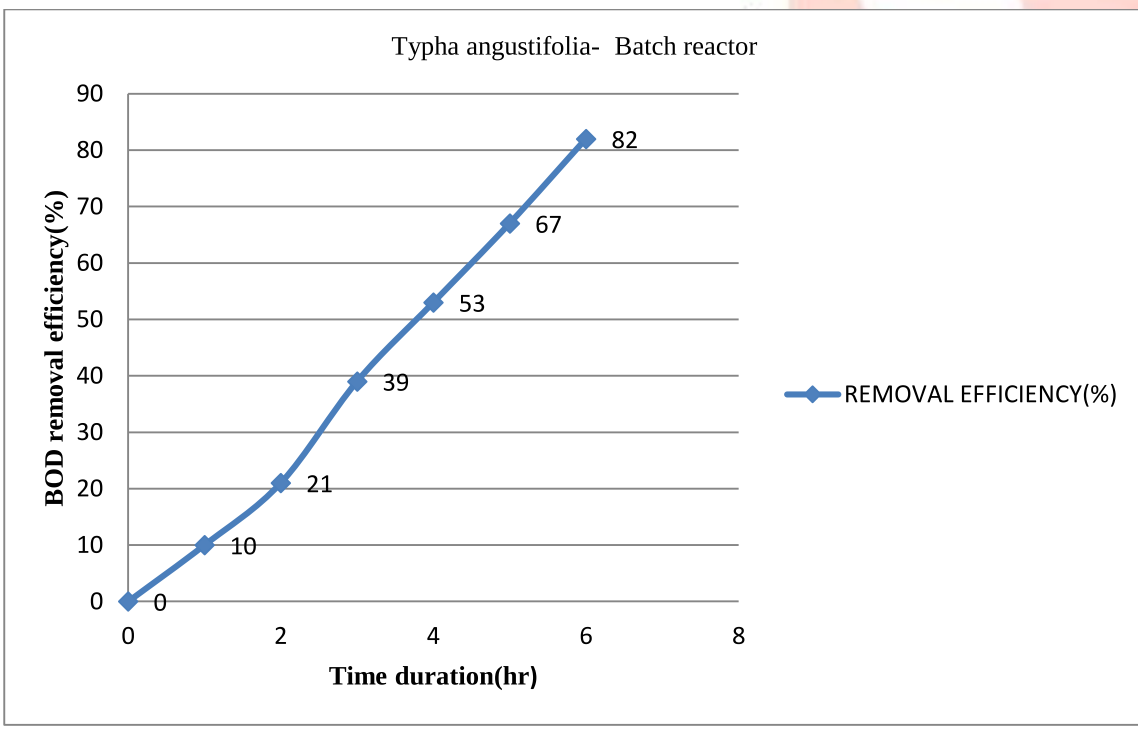
Graph 6: BOD removal efficiency of typha angustifolia

Graph 1 shows BOD removal efficiency in continuous flow reactor. Maximum removal efficiency is 89%. And in time duration of 15 to 45 minutes, higher removal efficiency is gained.



Graph 7: COD removal efficiency of typha angustifolia

Graph 1 shows COD removal efficiency in batch reactor. Maximum removal efficiency is 60%. And in time duration of 3 to 6 hours, higher removal efficiency is gained.



Graph 8: BOD removal efficiency of typha angustifolia

Graph 1 shows BOD removal efficiency in continuous flow reactor. Maximum removal efficiency is 82%. And in time duration of 2 to 3 hours, higher removal efficiency is gained.

V. CONCLUSION

The concept of natural wastewater treatment technologies involves and exploits the natural ability of ecosystem to purify the wastewater. A typical example of these systems is the aquatic ecosystems. One of the most popular natural technologies is the use of aquatic based treatment units, particularly the "wetlands". In the present study, use of aquatic plant for wastewater treatment as a means of natural wastewater treatment has been studied and to investigate the performance of the system, constructed wetland for wastewater treatment has been adopted. Typha angustifolia is more efficient than the water hyacinth. And BOD removal is higher than the COD removal.

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REFERENCES

[1] Aisha Saleem Khan, Mian Wajahat Hussain, Kauser Abdulla Mali., A possibility of using water lily (Nymphaea Alba L.) for reducing the toxic effects of chromium (Cr) in industrial wastewater, Pakistan Journal of Botany Volume 48, no 4, pg 1447 – 1452, 2016

[2] Ajayi, T.O., Ogunbayio, A.O., Achieving environmental sustainability in wastewater treatment by phytoremediation with water hyacinth (Eichhornia crassipes). J. Sust. Develop. 5, 80-90, 2012

[3] Akinbile CO, Ogunrinde TA, Che bt Man H, Aziz HA., Phytoremediation of Domestic Wastewaters in Free water Surface Constructed Wetlands using Azolla pinnata. Int J Phytorem 18(1): 54-61, 2016.

[4] Aziz HA, Adlan MN, Zahari MSM, Alias S., Removal of ammoniacal nitrogen (N--NH3) from municipal solid waste leachate by using activated carbon and limestone. Waste Manage Res 22(5): 371-375, 2004.

[5] Brima, E.I., Haris, P.I., Arsenic removal from drinking water using different biomaterials and evaluation of a phytotechnology based filter. Int. Res. J. Environ. Sci. 3, 39-44, 2014.

[6] Brix, H. and Shierup, H.H., The use of aquatic macrophytes in water pollution control, Ambio, 18, 100-107, 1989
Brix, H., Do macrophytes play a role in constructed treatment wetlands? Water Sci. Technol., 35, 11–17, 1997.

[7] C. Nivetha, S. Subraja, R. Sowmya, N. M. Induja, Water Lettuce for Removal of Nitrogen and Phosphate from Sewage, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 13, Issue 2 PP 104-107., 2016

[8] C.W. Sheffield, Water hyacinth for nutrient removal, Weed science volume 20, issue 5, pg – 423 -428, Weed Science Society of America, 1967

[9] Chaithra K.S, Dr. Lokeshappa B, Gabriel K.P., Water Hyacinth - A potential Phytoremediator and Biofertilizer., International Research Journal of Engineering and Technology (IRJET)., Volume: 03 Issue: 08 Pg – 1866 – 1873., Esat, 2016

[10] Chen X., Chen X, Wan X, Weng B, Huang Q., Water hyacinth (Eichhornia crassipes) waste as an adsorbent for phosphorus removal from swine wastewater. Bioresour Technol 101: 9025—9030, 2010.

[11] Cornwell, D.A., Zoltek, J., Patrinely, C.D, Nutrient removal by water hyacinths, Water Pollution Control Federation pg - 57-65, 1977

[12] Cristina S.C. Calheiros, Anto´nio O.S.S. Rangel, Paula M.L. Castro., Constructed wetland systems vegetated with different plants applied to the treatment of tannery wastewater., Water Research Volume 41, Issue 8, April 2007, Pg 1790-1798, 2007

[13] Dar, S.H., Kumawat, D.M., Singh, N. and Wani, K.A., Sewage treatment potential of water hyacinth (Eichhornia crassipes), Res. J. Environ. Sci., 5(4), 377-385, 2011
[14] Demirezen, D. & Aksoy, A., Accumulation of Heavy Metals in Typha angustifolia (L.) and Potamogeton pectinatus (L.) Living in Siltan Marsh (Kayseri, Turkey), Chemosphere, Volume - 56: pg - 685-696., Elsevier, 2004.

[15] Dhote, S. and Dixit, S., Water quality improvement through macrophytes: A case study, Asian J. Exp. Sci., 21(2), 427-430, 2007

[16] Guo BH, Tang HC, Song ZW, Xi JX., Theory of wastewater treatment by constructed wetlands and removal of nitrogen and phosphorus. Pollution Control Technology 16(4): 119-121, 2003

[17] Hefni Effendi, Bagus A. Utomo, Giri M. Darmawangsa., Phytoremediation of freshwater crayfish (Cherax quadricarinatus) culture wastewater with spinach (Ipomoea aquatica) in aquaponic system., Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society Volume 8, Issue 3., 2015

[18]Ismail Z, Othman SZ, Law KH, Sulaiman AH, Hashim R., Comparative Performance of Water Hyacinth (Eichhornia crassipes) and Water Lettuce (Pista stratiotes) in Preventing Nutrients Build-up in Municipal Wastewater. CLEAN--Soil Air Water 43(4): 521-531, 2015.

[19] Jamuna, S. and Noorjahan, C.M., Treatment of sewage waste water using water hyacinth - Eichhornia sp and its reuse for fish culture., Toxicol. Int., 16(2), 103-106, 2009

[20] Jerry Coleman, Keith Hench, Keith Garbutt, Alan Sexstone, Gary Bissonnette and Jeff Skousen, Treatment of Domestic Wastewater by Three Plant Species in Constructed Wetlands, Water Air and Soil Pollution, Water, Air, and Soil Pollution, pg 283–295, Kluwer Academic Publishers, 2001

[21] K. Sri Lakshmi , V. Hema Sailaja , M. Anji Reddy, Phytoremediation - A Promising Technique in Waste Water Treatment, International Journal of Scientific Research and Management (IJSRM) Volume-5, Issue - 06, page no - 5480-5489, 2017

[22] Liao, S.W. and Chang, W.L., Heavy metal phytoremediation by water hyacinth at constructed wetlands in Taiwan., Journal Aquatic Plant Management, Volume - 42, pg - 60-68., Elsevier , 2004.

[23] Lo Vun Yen & Kartini Saibeh., Phytoremediation using Typha angustifolia L. For mine water effluent treatment: case study of ex-mamut copper mine, ranau, sabah, The Journal of Science and Technology, Volume – 33, Borneo Science, 2013

[24] Mesania Rizwana, Marjadi Darshan and Desai Nilesh., Phytoremediation of Textile Waste Water Using Potential Wetland Plant: Eco Sustainable Approach International Journal of Interdisciplinary and Multidisciplinary Studies (IJIMS) Volume 1, No.4, pg - 130-138., Inderscience, 2014

[25] Mohanty, R. K., & Sinha, M. K., Use of aquatic macrophytes in water quality management. Fishing chimes, 18, 33-34, 1999.

[26] Moyo P, Chapungu L, Mudzengi B., Effectiveness of water Hyacinth (Eichhornia crassipes) in remediating polluted water: The case of Shagashe River in Masvingo, Zimbabwe. Adv Appl Sci Res 4 (4): 55-62, 2013.

[27] Nur Hamizah, H., PPAbdul Syukor A.R, PSulaiman, S., Performance of Typha Angustifolia and Lepironia Articulata For Upgrading Domestic Wastewater in An Integrated Phytogreen System, IJISET - International Journal of Innovative Science, Engineering & Technology, Volume. 2 Issue 12, 2015

[28] Ornes, W.H., Sutton, D.L., Removal of phosphorus from static sewage effluent by water hyacinth, Hyacinth Control journal, pg - 56-61., Journal of Environmental Quality, 1975.

[29] Piyush Gupta, Surendra Roy, Amit B. Mahindrakar., Treatment of Water Using Water Hyacinth, Water Lettuce and Vetiver Grass - A Review., Resources and Environment, Volume – 2, pg – 202 -215, Scientific & Academic Publishing, 2012

[30] Poole, W., Natural wastewater treatment with duckweed aquaculture, recycling resources, Ecological engineering for waste water treatment, Environment Research Forum, Volume. 5-6, Switzerland: Transtec Publications., 1996.

[31] Reddy, K.R. and Sutton, D.L., Water hyacinths for water quality improvement and biomass production, J. Environ. Qual., 13(1), 1-9, 1984

[32] Stefani, G.D., Tocchetto, D., Salvato, M. and Borin, M., Performance of a floating treatment wetland for in-stream water amelioration in NE Italy., Hydrobiologia, 674, 157-167, 2011

[33] Stoltz, E. & Greger, M., Accumulation Properties of As, Cd, Cu, Pb and Zn by Four Wetland Plant Species Growing on Submerged Mine Tailings. Environmental and Experimental Botany, 47: 271-280, 2002

[34] Sukhen Roy, J. K. Biswas, Sanjay Kumar., Nutrient Removal from Waste Water by Macrophytes – An Eco-Friendly Approach to Waste Water Treatment and Management, Energy and Environment Research; Vol. 4, No. 2; Canadian Center of Science and Education, 2014

[35] Taylor, G. J. & Crower, A. A., Uptake and Accumulation of Heavy Metals by Typha latifolia in Wetlands of the Sudbury, Ontario Region. Canadian Journal of Botany, 61: 63-73, 1983

[36] Truong, P.N.V.. Vetiver grass technology for mine rehabilitation. Office of the Royal Development Projects Board, Bangkok. Technical Bulletin No. 1999/2, 1999

[37] Ugya A.Y. and Imam T.S., The Efficiency of Eicchornia crassipes in the Phytoremediation of Waste Water from Kaduna Refinery and Petrochemical Company, IOSR Journal of Pharmacy and Biological Sciences, 2015

[38] Vajpayee, P., R.D. Tripathi, U.N. Rai, M.B. Ali and S.N. Singh., Chromium (VI) inhibition reduces chlorophyll biosynthesis, nitrate reductase activity and protein content in Nymphaea alba L., Chemosphere, vol – 41pg - 1075-1082., Elsevier, 2000

[39] Valipour, A., Raman, V.K. and Ghole, V.S., Phytoremediation of domestic wastewater using Eichhornia crassipes., J. Environ. Sci. Eng., 53(2), 183-190, 2011

[40] Vangronsveld, J., Herzig, R., Weyens, N., Boulet, J., Adriaensen, K., Ruttens, A., Thewys, T., Vassilev, A., Meers, E., Nehnevajova, E., van der Lelie, D., & Mench, Phytoremediation of Contaminated Soils and Groundwater: Lessons from the Field. Environmental Science and Pollution Research, 16: 765-794, 2009.

[41] Wooten, J.W. and Dodd, J.D., Growth of water hyacinths in treated sewage effluent, Econ. Bot., 30, 29-37, 1976
Xia, H. and Ma, X., Phytoremediation of ethion by water hyacinth (Eichhornia crassipes) from water., Bioresource Technology, 97, 1050-1054, 2006

[42] Zayed, A., Gowthaman, S. and Terry, N., Phytoaccumulation of trace elements by wetland plants: I. Duckweed, Journal of Environmental Quality, V - 27, pg - 715-721., 1998