Valuable Product from Water Hyacinth – Review Paper

Mukesh Dwivedi[1] , Anjani Kumar Dwivedi[2]

[1] *M.Tech. Department of Chemical Engineering, Ujjain Engineering College, Ujjain-456010, (Madhya Pradesh), India .*

[2] *Professor & Head Department of Chemical Engineering, Ujjain Engineering College, Ujjain-456010, (Madhya Pradesh), India.*

---***---

Abstract - *Recently in India Swachh Bharat Abhiyan and River water cleanliness programmes are at crucial stage. So as to support the clean India campaign and Green India ideology one step should be taken to clean Rivers by making them free from water hyacinth. It is also help in conservation of river ecosystem. Water hyacinth in still river also has adverse effect on human health so, as to prevent the water hyacinth build up in the river, we have to develop a commercial and economics means. And for that we should also have idea about characteristics and constituents of water hyacinth. This gives in valuable products like biogas, bioethanol, biohydrogen, biofertilizers and uses like fish feed as discussed in this study.*

Key Words: **Eichhornia crassipes; Water hyacinth; bioethanol; biofertilizer.**

1. INTRODUCTION

Eichhornia crassipes (Mart.) Solms called water hyacinth could be a free-floating perennial aquatic plant happiness to the Pontederiaceae. It's one in every of the foremost productive plants on the planet and is taken into account the world's worst aquatic weed. The weed is thought as Jal khumbe in Hindi, Pisachitha tamara in Telugu, Akasa or Vengaya tamarai in Tamil and as Kola vazha in Malayalam (Vidya & Girish, 2014). Water hyacinth (WH) could be a free floating, perennial water plant originated from Amazon River basin and have distributed throughout the globe. It's exhibited extraordinarily high growth rates and therefore the coverage of waterways by WH has created many issues as well as destruction of eco systems, irrigation issues and additionally as a dipteron breeding place resulting in increase in dipteron population. it's thought-about because the most efficient plant on earth and currently thought-about as a significant threat to biodiversity(Sindhu et al, 2017).In the last 3 decades a interest within the world is aroused by the potential of victimisation the biological ways within the waste water treatment, whose application as of natural and not artificial procedures of tertiary process of effluents provides the effluents of needed quality in a very economically acceptable manner within the technically simple structures. The capability of water plant(Eichhornia crassipes (Martius) Solms-Laubach) as a very promising plant with tremendous application in wastewater treatment is already proven(Jafari, 2010).This weed may be a drawback particularly in tropical and semitropical countries wherever environmental conditions give a year spherical growing amount. The natural loss of water from the water surface by evaporation is believed to extend through transpiration from the leaves of water plant by a minimum of 40–50%.Due to this generally it's known as "shokh samunder" in Asian country. The dense growth of water plant obstructs water flow in irrigation channels, interferes with navigation and electricity power generation. The flow of water is reduced by 40–95% and roughness constant will increase from zero.024 to 0.055 in irrigation channel (Mathur & Mathur, 2018). It grows in mats up to two meters thick which may cut back lightweight and oxygen, modification water chemistry, have an effect on flora and fauna and cause important increase in water loss because of evapotranspiration. It conjointly causes sensible problems for marine transportation, fishing and at intakes for hydro power and irrigation schemes. It's currently thought of a heavy threat to diversity. The plant originated within the Amazon Basin and was introduced into several components of the planet as a decorative garden pool plant attributable to its beauty. It absolutely was initially introduced as a decorative plant in India in 1896 from Brazil (Mathur, 2013).

Fig -1: Water hyacinth plants (source Mathur & Mathur, 2018)

1.1 CHEMISTRY OF WATER HYACINTH: (JAFARI 2010)

- Fresh plant contains 95.5% moisture, 0.04% N, 1.0% ash, 0.06% P2O5, 0.20% K2O, 3.5% organic matter.
- On a zero-moisture basis, it is 75.8% organic matter, 1.5% N, and 24.2% ash.
- The ash contains 28.7% K2O, 1.8% Na2O, 12.8% CaO, 21.0% Cl, and 7.0% P2O5.

- The CP contains, per 100 g, 0.72 g methionine, 4.72 g phenylalanine, 4.32g threonine, 5.34 g lysine, 4.32 g isoleucine, 0.27 gvaline, and 7.2 g leucine.
- Water hyacinth roots naturally absorb pollutants, including such toxic chemicals as lead, mercury, and strontium 90 (as well as some organic compounds believed to be carcinogenic) in concentrations 10,000 times that in the surrounding water.

2. Water Hyacinth Control

Methods to manage Eichhornia spesiosa will be classified into: chemical, biological and mechanical ways. Chemical management ways rely on many herbicides to manage the plant. However, these ways have many disadvantages like the adverse impact on the environment and public health .the biological management ways on an attempt bases have been dole out to manage Eichhornia spesiosa victimisation some pests as flora pathogens, mites,snails or insects and bound herbivorous fish species, however, the results weren't satisfactory. Moreover, introducing new pests to the setting could disturb the natural balance and also the biological diversity (M.F.Abdel-sabour 2010).

Water hyacinth is extraordinarily tough to eradicate once established. The goal of most management efforts is to attenuate economic prices and ecological amendment. Recent literature on management of Eichhornia crassipes focuses on techniques to get rid of the weed, however, very little has been done to assess the total extent of ecological changes that will occur in response to the institution of this weed. Efforts are created by varied countries to regulate or manage the Eichhornia crassipes. These strategies vary from mechanical or physical removal of the hyacinth, biological management to chemical use; however no methodology has fully succeeded in dominant the menace. There are unit 3 main strategies of management of this ill-famed weed specifically physical, chemical and biological. Physical management involves each manual and mechanical removal, a tedious and long exercise, involving the utilization of big and extremely big-ticket machinery and human labour (Andika et al, 2013).

Chemical management victimisation herbicides, the foremost well-liked of that a pair of, 4-dichlorophenoxy acetic acid, has to date been the most weapon employed in dominant water plant. It is effective and comparatively cheaper than the opposite mechanical and manual management methods. However, their long-run effects on the atmosphere are unknown and therefore the sprayed plants are left to rot within the water, inflicting pollution and aggravated eutrophication. Biological management, on the opposite hand, guarantees to be a less expensive control methodology within the end of the day as a result of its self-perpetuating and encompasses a lasting effect (Mathur & Mathur 2018).

3.Value added products from water hyacinth:

Several price adscititious product will be made from WH residue.This embrace biogas, bioethanol, biohydrogen, biopolymer, biobutanol, composites, biofertilizers, fish feed, high calorific value fuel, fuel briquet, superabsorbent compound and xylitol. Additionally, WH may also be used as substrate for mushroom cultivation and for treatment of assorted industrial effluents for the removal of significant metals.

3.1 Biogas

Biogas may be a gas mixture created by the anaerobic fermentation of organic materials by methanogenic microorganism. It consists of a mix of methane, CO2, water, hydrogen sulfide and ammonia. WH is a possible supply for biogas production. Several reports were out there for the potential of WH as a raw material for the assembly of biogas. Anaerobic co-digestion of WH in conjunction with scrap and elephant grass for biogas production at laboratory scale was evaluated by Okewale et al. (2016). The study unconcealed that co-digestion of WH and elephant grass gave a higher yield of biogas production. Method parameters like temperature, pH and retention time have a big impact on biogas yield. The very best alkane content of sixty two was ascertained in sterilizer1 that contains WH, elephant grass, scrap and water gave a yield of two.303 L once sixty days of incubation.

Njeru and Njeru, 2014; reported WH has developed associate degree environmentally sound method of utilization of weed from lake, Kenya as feedstock for biogas production. The uprooted weeds were pulped and mixed with water at a quantitative relation of 1:1 and 1:3 with junk to supplement decomposition microorganisms. The mixture was loaded into bioreactor and gas yield, chemistry parameters and bioreactor temperatures monitored throughout the assembly period. Gas integrative analysis of the biogas was administered with a Gas Chromatograph in addition to a Thermal physical phenomenon detector (GC-TCD). The Biogas contained 49 - 53 alkane, 30 - 33% CO2, 5 – 6% nitrogen and traces of hydrogen sulphide. Optimum gas production happens at the 21st day when feeding the autoclave.

Singhal and Rai, 2003; Investigated biogas production from WH.The plant grows well in diluted factory and extremely acidic still effluents and takes up serious metals and different toxic materials for their growth. Utilization of the suspension of WH used for phytoremediation made considerably additional biogas than that of plants mature in deionized water. Most biogas production
was ascertained in 9–12 days.

3.2 Biofertilizer

Water hyacinth can be used on the land either as manure or as compost. As a manure it may be plowed into the bottom or used as mulch.The plant is good for composting. microbic decomposition breaks down the fats, lipids, proteins, sugars and starches. The mixture may be left in piles to compost; the warmer climate of tropical countries accelerates the method manufacturing, rich pathogen free, compost which may be applied on to the soil. In Sri Lanka Water Hyacinth is mixed with organic municipal waste, ash and soil, composted and sold to native farmers and market gardeners.

Nath and singh 2016, worked on the management of water hyacinth and observation of nutritional status like pH, electrical conductivity (EC), total organic carbon (TOC), total Kjeldahl nitrogen (TKN), C/N ratio, total phosphorus and total calcium (TCa) of liquid bio-fertilizer (vermiwash) before and after vermicomposting of feed materials of different combinations of buffalo dung (BD) with water hyacinth (WH) and gram bran (GB).and observed that the different combinations of buffalo dung with gram bran and water hyacinth (E. crassipus) can be converted into rich organic liquid bio-fertilizer through vermicomposting with help of E. fetida. Vermicomposting resulted in the decrease in level of pH, EC, TOC and C/N ratio, but increase in TKN, TAP, TCa, and TK level. The value of C/N ratio, below 20, for the vermicompost suggests the satisfactory degree of maturity. The vermiwash obtained from the combination of BD + GB + WH (1:2:1) has maximum rich organic nutrients.

The study conducted by (Vidya and Girish , 2014) discovered that WH is used as a bio fertilizer once incorporating to soil inflated the performance of wheat plant. In this study wheat crop was treated with compost derived from WH and were big for fifteen days. Management experiments were carried out while not WH compost. Physical and chemical parameters were studied. The physical parameters like proportion germination, length of root, length of shoot, biomass content and root: shoot ratios were studied. Chemical parameters like pigment, reducing sugar and super molecule content were conjointly evaluated. The study revealed that each physical and chemical parameter had higher values as compared to regulate. WH may be a sensible absorbent material of N, P and K from the water and may be used as a compost material. The results indicate the potential of WH as organic manure.

Gupta et al. 2007; Investigate the potential of water hyacinth (WH) spiked with cow dung (CD) into vermicompost. Five vermireactors containing WH and CD in different ratios were run under laboratory conditions for 147 days. They observed if WH was mixed with up to 25% in CD (dry weight), the vermicompost quality was not affected; but a higher percentage of WH in the feed mixture retarded the growth and fecundity of the worms used and also affected the nutritional quality of vermicompost.

3.3 Bioethanol

Depletion of fossil fuels and increase in energy consumption leads to hunt for various methods of energy. Utilization of lignocellulosic feed stock will be thought-about as an appropriate biomass for production of renewable biofuels like bioethanol. Production of fuels from waste biomass like WH plays a very important contribution in independent society. Bioethanol production from WH involves 3 stages-pretreatment,chemical reaction and fermentation.Bioethanol could be a renewable fuel and its importance will increase due to depletion of fossil fuels, increase of oil worth and inexperienced house impact.

Gunja et al., 2016; Observed bioethanol production from WH using a thermo-tolerant microorganism isolated from a sugarcane field.The novel isolate made 13.45 g/l of bioethanol at Associate in Nursing incubation temperature of 44^0C. usually fermentation is applied with Saccharomyces cerevisiae, however throughout summer the temperature raises up to 45^0C or higher than at that the yeast cannot survive and it is troublesome for beverages industries to keep up the temperature at 32-35^0C for maintaining the viability of yeast. thus the utilization of thermo-tolerant microorganism appears promising.

Bioethanol production from recent and dry WH exploitation ruminant microorganisms and ethyl alcohol producers were evaluated by Sambo et al. (2015). The study discovered the potential of microorganism and flora isolates obtained from first stomach of goat, ram and cow to digest cellulosic materials of WH. Fermentation of the WH product was distributed with Saccharomyces cerevisiae and Zymomonas mobilis. The results indicate that Zymomonas mobilis made more bioethanol than Saccharomyces cerevisiae moreover because the recent WH biomass made additional bioethanol than the dried WH biomass. The employment of WH for the assembly of bioethanol will go an extended means in reducing dependence on fuel.

Ganguly et al., 2013; Analysed bioethanol production from WH hydrolysate using 3 completely different strains – Pichia stipitis, Candida shehatae and yeast.WH biomass was pretreated with acid and alkali and also the alkali pretreatment was found to be more effective in polymer removal thereby enhancing the polysaccharide and hemicellulose content of WH by removing polymer. It was observed that accelerator saccharification was more practical than saccharification with whole cell biocatalysts. The assembly of bioethanol is increased by victimisation each monosaccharide and simple sugar utilizing strains at the same time. Most bioethanol yield was observed with Pichia stipitis (3.49 g/l), followed by fungus shehatae (3.45 g/l) and three.13 g/l for yeast.

3.4 Biohydrogen

Due to depletion of fossil fuels and increase in energy demand scientists everywhere the globe square measure sorting out various ways of energy. Biohydrogen is energy since its combustion generates solely water and warmth in addition as has high energy yield of 122 kJ/g. historically gas is created by chemical processinvolving electrolysis of water and steam reforming. These processes don't seem to be economically viable since it needs high energy input and high reaction temperature. Biohydrogen production is eco-friendly and might be created from mixed or pure culture.Many anaerobic microorganisms will turn out biohydrogen from organic wastes (Sindhu et al., 2017).

Pattra and Sittijunda (2015) optimized various method parameters affecting acid reaction of WH for the assembly of biohydrogen. Response surface methodology (RSM) and central composite style (CCD) were adopted for the optimisation studies.The optimum conditions for acid reaction of WH were determined as latent period of 7.73 h, dilute H_2SO_4 concentration of 1.31% (v/v) and stirring speed of 264.41 revolutions per minute yielded most total reducing sugar of 13 g/l. Fermentation of the hydrolyzate yielded 127.6 mM
H_2/l.

Muanruksa et al., 2016; Reported direct biohydrogen production from WH victimisation clostridia diolis C32-KKU. polyose and hemicelluloses given in WH is directly hard by cellulolytic bacterium clostridia diolis C32-KKU to biohydrogen. Various process parameters touching biohydrogen production were optimized for each static and shaking modes of cultivation. The study discovered that shaking mode was simpler than static mode for biohydrogen production. most biohydrogen production (19 ml/l) was discovered at pH scale 5.5 and WH biomass loading of 19gdw/l. The results of the study indicate that direct biohydrogen production from WH might be a possible approach.

3.5 Fish feed

The Chinese grass carp may be a quick growing fish that grub aquatic plants. It grows at an incredible rate and reaches sizes of up to 32 kilogram (National Academy of Sciences 1979). It's associate edible fish with tasty pork. It'll eat submerged or floating plants and conjointly bank grasses. The fish is used for weed control and can eat up to 18–40% of its own weight in a very single day (Gopal 1987). Eichhornia crassipes has conjointly been used indirectly to feed fish. Dehydrated water hyacinth has been value-added to the diet of catfish fingerlings to extend their growth (Gopal 1987). It's conjointly been noted that decay of Eichhornia crassipes once chemical management releases nutrients that promote the expansion of flora with resultant will increase in fish yield (Gopal 1987).

3.6 Water purification

Water hyacinths are often wont to aid the method of waterpurification either for drink or for liquid effluent from waste matter systems. In a drink treatment plant, the water plant has been used as a part of the pre-treatment purification step. Clean, healthy plants are incorporated into water clarifiers and facilitate with the removal of little flocs that stay when initial coagulation and material removal or subsiding. The result's a big decrease in turbidity thanks to the removal of flocs and additionally slight reduction in organic matter in the water. In waste matter systems, the basis structures of water plant (and alternative Aquatic plants) offer an appropriate atmosphere for aerobic bacterium to operate (Mathur & Mathur 2018).

Rezania et al., 2015; Studied Water Hyacinth (Eichhornia crassipes) was used to treat domestic wastewater. Ten organic and inorganic parameters were monitored in three weeks for water purification. The six chemical, biological and physical parameters included Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3-N), Total Suspended Solids (TSS) and pH were compared with the Interim National Water Quality Standards, Malaysia River classification (INWQS) and Water Quality Index (WQI).and obseserved Reduction in the most of the parameters like: DO, COD, BOD, (NH_3-N) and TSS by Eichhornia crassipes occurred which is due to successful phytoremediation treatment system. In this case, increase of CO_2 levels from photosynthesis and microbial activities have played key role. Based on the results, the water quality has been improved from class IV and III to class II which is due to 38% to 96% of reduction of parameters. In this study, highest reduction was in range of 13- 17th day of the experiment but optimum was recorded on day 14 in continuous system.

4. CONCLUSION

Form above literature we come to the following conclusions regarding water hyacinth.

- Removing water hyacinth promotes cleaning of river.
- It reduces harms to ecosystem.
- It is also used in producing bio product as discussed.

From this study we can conclude that a commercial method should be developed to control and removing of water hyacinth.

ACKNOWLEDGEMENT

The authors are thankful to department of chemical engineering and Ujjain engineering college, Ujjain (M.P.) for permission to collect literature from the library and their cooperation.

REFERENCES

- Abdel-Sabour, M. F. "Water hyacinth: available and renewable resource." Electronic Journal of Environmental, Agricultural & Food Chemistry 9.11 (2010).
- Darius O. Andika, Jane Akinyi Ogada Patrick O Hayombe. Producing Liquid Organic Fertilizer from Water

Hyacinth; A Case of Lake Victoria, Kenya. International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064 Index Copernicus Value (2013): 6.14 | Impact Factor (2014): 5.611

- Gopal B (1987) Aqatic Plant Studies 1. Waterhyacinth. Elsevier Publishing, New York, USA
- Gunja., Vipin, G., Priyanka, J., Kant, S. C., Dixit, A. K., Jain, R. K., 2016. Production of bioethanol from water hyacinth by isolated thermotolerant bacteria. Inter. J. Curr. Sci. Technol. 4, 219-223.
- Gupta, Renuka, et al. "Development of a water hyacinth based vermireactor using an epigeic earthworm Eisenia foetida." Bioresource technology 98.13 (2007): 2605-2610.
- Jafari, N. "Ecological and socio-economic utilization of water hyacinth (Eichhornia crassipes Mart Solms)." Journal of Applied Sciences and Environmental Management 14.2 (2010).
- Kivaisi, A. K., and M. Mtila. "Production of biogas from water hyacinth (Eichhornia crassipes)(Mart)(Solms) in a two-stage bioreactor." World Journal of Microbiology and Biotechnology14.1 (1997): 125-131.
- Malik, Anushree. "Environmental challenge vis a vis opportunity: the case of water hyacinth." Environment international 33.1 (2007): 122-138.
- Mathur, Priti, and S. M. Mathur. "Water Hyacinth: A Useful Plant to Improve Rural Economy." Energy and Environment. Springer, Singapore, 2018. 31-38.
- Mathur, Shailendra Mohan. "Water hyacinth (Eichhornia crassipes [Mart.] solms) Chopper cum Crusher: A Solution for Lake Water Environment." J. Energy Technol. Policy 3.11 (2013): 299-306.
- Muanruksa, P., Khongsa, N., Fiala, K., 2016. Optimization of conditions for direct bio-hydrogen production from water hyacinth by Clostridium diolis C32-KKU. KKU Res. J. 21, 267-279.
- Nath, Shesh, and Keshav Singh. "Analysis of different nutrient status of liquid bio-fertilizer of different combinations of buffalo dung with gram bran and water hyacinth through vermicomposting by Eisenia fetida." Environment, development and sustainability 18.3 (2016): 645-656.
- Njeru, Purity Muthoni, and Paul Njogu. "Conversion of Water Hyacinth Derived Biogas to Biomethane for Electricity Generation in Kenya: A Waste to Energy (WtE) Approach." Proceedings of Sustainable Research and Innovation Conference. 2014.
- Nigam, J. N., 2002. Bioconversion of water-hyacinth (Eichhornia crassipes) hemicellulose acid hydrolysate to motor fuel ethanol by xylose–fermenting yeast. J.Biotechnol. 97, 107–116.
- Okewale, A. O., F. Omoruwou, and R. O. Ojaigho. "Alternative Energy Production for Environmental Sustainability." British Journal of Renewable Energy 1.02 (2016): 18-22.
- Pattra, S., Sittijunda, S., 2015. Optimization of factors affecting acid hydrolysis of water hyacinth stem (Eichhornia crassipes) for bio-hydrogen production. Energy Procedia 79, 833 – 837.
- Raja, S. A., Lee, C. L. R., 2012. Biomethenation of water hyacinth using additives under forced mixing in a bio reactor. Int. J. Chem. Res. 2, 1524.
- Rezania, Shahabaldin, et al. "The efficient role of aquatic plant (water hyacinth) in treating domestic wastewater in continuous system." International journal of phytoremediation 18.7 (2016): 679-685.
- Sambo, S., Faruk, U. Z., Shahida, A., 2015. Ethanol production from fresh and dry water hyacinth using ruminant microorganisms and ethanol producers. A Global Advan. Res. J. Biotechnol. 4, 023-029.
- Shankar, B. B., Patil, J. H., Muralidhara, P. L., Ramya, M. C., Ramya, R., 2013. Effect of substrate concentration on biomethanation of water hyacinth. Inter. J. Chem.Environ. Biol. Sci. 1, ISSN 2320–4087.
- Sindhu, R.; Binod, P.; Pandey, A.; Madhavan, A.; Alphonsa, J. A.; Vivek, N.; Gnansounou, E.; Castro, E.; Faraco, V. Water hyacinth a potential source for value addition: An overview. Bioresour. Technol. 2017, 230, 152–162.
- Singhal, V., and J. P. N. Rai. "Biogas production from water hyacinth and channel grass used for phytoremediation of industrial effluents." Bioresource technology 86.3 (2003): 221-225.
- Soontornchaiboon, W., Kim, S. M., Pawongrat, R., 2016. Effects of alkaline combined with ultrasonic pretreatment and enzymatic hydrolysis of agricultural wastes for high reducing sugar production. Sains Malaysiana 45, 955–962.
- Vidya, S. H. A. R. D. A., and L. A. K. S. H. M. I. Girish. "Water hyacinth as a green manure for organic farming." International Journal of Research in Applied, Natural and Social Sciences2.6 (2014): 65-72.

BIOGRAPHIES

Mukesh dwivedi
M.Tech. Department of Chemical Engineering, Ujjain Engineering College, Ujjain 456010 (M.P.)

Anjani Kumar Dwivedi
Professor & Head Department of Chemical Engineering, Ujjain Engineering College, Ujjain-456010, (M.P.)