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Dynamics of Water Weed *Eichhornia Crassipes*: A Review

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Abstract-Water hyacinth (Eichhornia crassipes) an aquatic weed discovered more than 200 years back from south America with a massive spread throughout the world possessing a great challenge of its management, had shown a ray of hope after its useful application as a food source, fertilizer, biofuel, fodder, fiber, phytoremediation, and medicine in tropics and sub tropics. The use of chemical, physical and biological means is among many efforts to destroy water hyacinths but there is also a positive attitude to utilize plant in a profitable way. It has been scientifically tested that the roots, leaves and flowers of this plants have chemical constituents that can be able to cure various ailments. The presence of high nitrogen, cellulose and hemicellulose and low lignin makes it a best alternative as biofuel. It can be used as an herbicide and in phytoremediation of harmful pollutants from waste water. Utilization as animal feeds, craft materials such as bags, mats, and other accessories, and biofertilizer to enhance yield attributes of the crops are other important benefits of this aquatic plant. This review presents the beneficial information regarding, medicinal, biofuel generation, phytoremediation property and other ecological and economical value for a sustainable use and management of water hyacinth.
Key words: water hyacinth, aquatic weed, phytoremediation, biofuel, medicine, sustainable use.

I. INTRODUCTION

Water hyacinth (*Eichhornia crassipes*) considered one of the most productive plants on earth and among one of the top ten world's worst weeds [1] is known to cause significant ecological and socio-economic effects altering water clarity and decrease phytoplankton production, dissolved oxygen, nitrogen, phosphorous, heavy metals and concentrations of other contaminants [2]. It spread to tropical and subtropical regions by humans and invaded about 62 countries in Africa, Asia and North America, between 40 degrees north and 45 degrees south [1]. The weed suppresses and occupied ecological niches and thus disrupted plant-animal-physical environment interactions and balance [3]. The weed known to out-compete native plants, negatively affect microbes including phytoplankton [4] also causes fish kills due to oxygen depletion [5]. The aquatic weed increases evapo-transpiration, providing favorable conditions for disease-carrying vectors, slowing down of the water flow and causes flooding [6].

Beside these negative impacts water hyacinth has also been found to beneficial. The methods of converting the plant material into valuable products have emerged in several countries. The plant has been found to be useful in solving man created problems of pollution in water bodies. The plant is used to treat waste water from dairies, tanneries, sugar factories, pulp and paper industries, palm oil mills, distilleries, etc. The water hyacinth have been found to have potential for use as phytoremediation, organic fertilizer, biogas production, human food, fiber, animal fodder [7]. In several parts of the world as in Taiwan, Java and the Philippines, the inhabitants sometimes eat the young leaves and in Malaysia various communities cook the leaves and stems into a mash and feed it to their pigs [8]. Water hyacinth can be used fresh, ensiled or wilted to animals. Whole plants, chopped or ground can used as feedstuffs for both ruminants and monogastrics [9]. The water hyacinth plants mixed with molasses and pig manure were found to be used for silage production containing protein and dry matter, suitable for use as animal feed. The composted water hyacinth plant also contains N, P and K thus found to be technically and economically feasible to be implemented at farm scale levels [10]. Its utilization for energy production seems to be highly beneficial [6] and the option of biogas production as a way of energy exploration may not only sustain the energy availability but also improve environmental sustainability by improving the social, economic and physical well-being of the environment [11]. It was experimentally proven that the mulching with dried water hyacinth have increased the yield and potato tuber size, along with reducing the bacterial wilt incidence and lowers down late blight incidence in the crop [12]. Thus this water weed that is considered destructive to aquatic life can be potentially converted into a useful plant material of social and economic benefits.

II. BENEFITS OF WATER HYACINTH AS MEDICINE

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Water hyacinth provide rich source of natural bioactive compounds with antimicrobial, antitumoral, antiviral, and antioxidant activities confirmed by spectroscopic methods showing the presence of different compounds of variable anticancer and antioxidant activities leading to its greatest activities [13]. The fresh plant shoot contain alkaloids, flavonoids, phenols, sterols, terpenoids, anthoquinones and protein [14]. The weed shows highest percentage of tannins and alkaloids and moderate presence of glycosides and saponins and flavonoids thus making it an effective antimicrobial and chemotherapeutic agent [15]. Extracts, as well as pure compounds isolated from this plant, have been demonstrated to possess pharmacological activities [16]. This aquatic weed has biologically active phytochemicals compounds that are useful to treat infectious diseases caused by bacterial and fungal pathogens. Jayanthi and Lalitha [17] experimented solvent extracts of water haycinth against bacteria *Staphylococcus albus* using disc diffusion method and a fungal stains *Mucor sp* using streak plate method and observed that acetone extract were found superior among other extracts thus adding the value of the plant in pharmaceutical field as an antimicrobial agent. According to Lalitha and Jayanthi [14] the aqueous, chloroform, ethanol and ethyl acetate extracts were found effective against two bacteria *Micrococcus luteus* and *Rhodospirillum rubrum* and two fungi *Monoscus ruber* and *Rhodospirillum rubrum.*

In recent years the potentiality of water hyacinth powder as natural polymers and its rate retardant activity has been tested in form of tablets using wet granulation method with 8% starch as granulating agent and angle of repose, Carr's Index and Hausner ratio were calculated along with Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC), and Scanning Electron Microscopy (SEM) were also performed proving formulation F-1 (5% of Water hyacinth) as the best fitted formula in sustained release drug formulations [18]. Reducing power assay of the solvent extracts of water hyacinth at different concentrations and time delay was reported to be linearly proportional to the concentration and time and was found to increase with increase in concentration and time suggesting the potential of development of useful natural antioxidants [19].

Baral et al [20] have experimentally proven that the ethanolic hot and cold extract of water hyacinth possessing major components like saponins, polyoses, alkaloid salts, and reducing compounds, shows more antibacterial activity far better than the chloroform fraction, while they share the same value and possess same effectiveness against the different fungi. Shanab et al [4] used thin layer chromatography (TLC) and paper disc diffusion bioassay and observed antibacterial activities of water hyacinth against both the Gram positive bacteria; *Bacillus subtilis* and *Streptococcus faecalis*; and the Gram negative bacteria; *Escherichia coli* and *Staphylococcus aureus* due to the presence of an alkaloid and antialgal activity against the green microalgae; *Chlorella vulgaris* as well as the cyanobacteria; *Spirulina platensis* and *Nostoc piscinale* due to four phthalate derivatives.

III. ALTERNATIVE OF FOSSIL FUEL

In this age of increasing energy costs water hyacinth holds a strong promise for alternatives to biofuel industry. The water hyacinth that grows at a very rapid pace and contains very high nitrogen and low lignin content (10%) and high amounts of cellulose (20%) and hemicellulose (33%) that are more easily converted to fermentable sugar thus resulting in enormous amount of utilizable biomass for the biofuel industry. They can be collected from unused commercial ponds or lakes, cutted in to slice mats and pressed to remove approximately 97% water, and can be further treated with dilute acids to get biomass which is processed for transesterification reaction [21]. According to Bhattacharya and Kumar [22] this invasive aquatic weed could be sustainably managed in their natural ecosystem and used in biofuel production, generating ample avenues of research, development and marketing of its end product (i.e. bioethanol and biogas). Biomass-to-liquids (BTL) technologies based on water hyacinth may substantially increase the portfolio of available biomass resources. The plant shows lower heating value (LHV) which is very low when compared to dryer crop residues and forestry biomass resources, and thus it may be treated with heat for BTL processing. The water hyacinth has also been a promising source of hydrogen (which demands substantial changes in motor engines), can be gasified in supercritical water (pressure over 221 bars), producing a balanced gas mixture of hydrogen and carbon dioxide. Thus, the use of water hyacinth is appropriate due to minor energy investment for cropping and little trace gas emission footprints for biomass cropping and processing (mitigation of land-use and fossil trace gas emissions for energy, pesticides, herbicides and fertilizers). A significant amount of this material would biogenically result in methane emissions, and thus its use as biofuel would simply be a better use for a common atmospheric emission of biogenic methane [23].

IV. ECOLOGICAL IMPORTANCE

Water hyacinth is although reported to be as one of the most problematic plants worldwide but its quest for nutrient absorption has

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provided way for its usage of herbicidal control [24]. According to Geethu et al [25] chromatography and Fourier transform infrared spectroscopy (FTIR) were the best tools for identification of secondary metabolic fingerprint for *Eichhornia crassipes* and the FTIR signal at 900, 1500, 1714, 3000, 3100cm-1 were considered as an indicator of polyphenols indicating analyzing the phytochemicals qualitatively and quantitatively to design a plant based herbicide. Chai et al [26] observed that weed extract reduced the total percentage and speed of germination, root length, fresh weight along with biochemical changes like increase in hydrogen peroxide content, cell wall-bound peroxidase activity, and also inhibits soluble peroxidase activity without altering the malondialdehyde content in the root tissues of non-pregerminated and pregerminated seedlings of *Mimosa pigra*, an aquatic weed.

V. PHYTOREMEDIATION

The fast growth of population has caused rapid increase in the domestic sewage pollution in various cities and water hyacinth (*Eichhornia crassipes)* can be a best tool for phytoremediation technology to solve the sewage pollution [27]. This aquatic weed helps in bio-purifications of coal mine and municipal wastewater by significant reduction in pH, Nitrate, Sulphate, and iron content of the water. Water hyacinth has potentiality for the removal of toxic chemical present in different types of wastewater, along with integrated biological control and watershed management and in focus to the future aspects of phytoremediation, the plant can be utilized for their sustainable management in treating waste water [24]. *Eichhornia crassipes* tested for its ability to bioconcentrate toxic metals, had the lowest and the highest tolerance indices for Hg and Zn, and have shown a significant reduction in biomass production in metal treated plants. Further all trace elements were found accumulated to higher concentrations in roots than in shoots. Trace element concentrations in tissues and the bioconcentration factors (BCF) were proportional to the initial concentration of individual metal in the growth medium and the duration of exposure proving that it is a promising plant species for remediation of natural water bodies and/or wastewater polluted with low levels of Zn, Cr, Cu, Cd, Pb, Ag and Ni [28]. The digested samples of the plant analyzed for four metals (Zn, Cu, Cd and Cr) by a Perkin Elmer 3000DV Inductively Coupled Plasma- Atomic Emission Spectrometer (ICP-AES) has removed appreciable amount of heavy metals that was recorded maximum on the 10th day of exposure and the roots were proved better accumulator of the metals than leaves [29]. Water hyacinth also has potential of removing approximately more than 90% of Cu and Cd from polluted water and at all levels the plants accumulated the highest concentration of Cd in roots, while the highest concentration of Cu was accumulated in stems. The biocencentration factor (BCF) of Cu was higher than that of Cd, suggesting that the accumulation potential for Cu was higher than that for Cd and could be used to treat waste-water contaminated with low Cu and Cd accumulations [30].

Therefore this study shows that water hyacinth considered a harmful water weed but has potentiality to be utilized in various medicinal, biofuel, fodder and bioremediation techniques through a safe and clean technology for the human and environmental benefits.

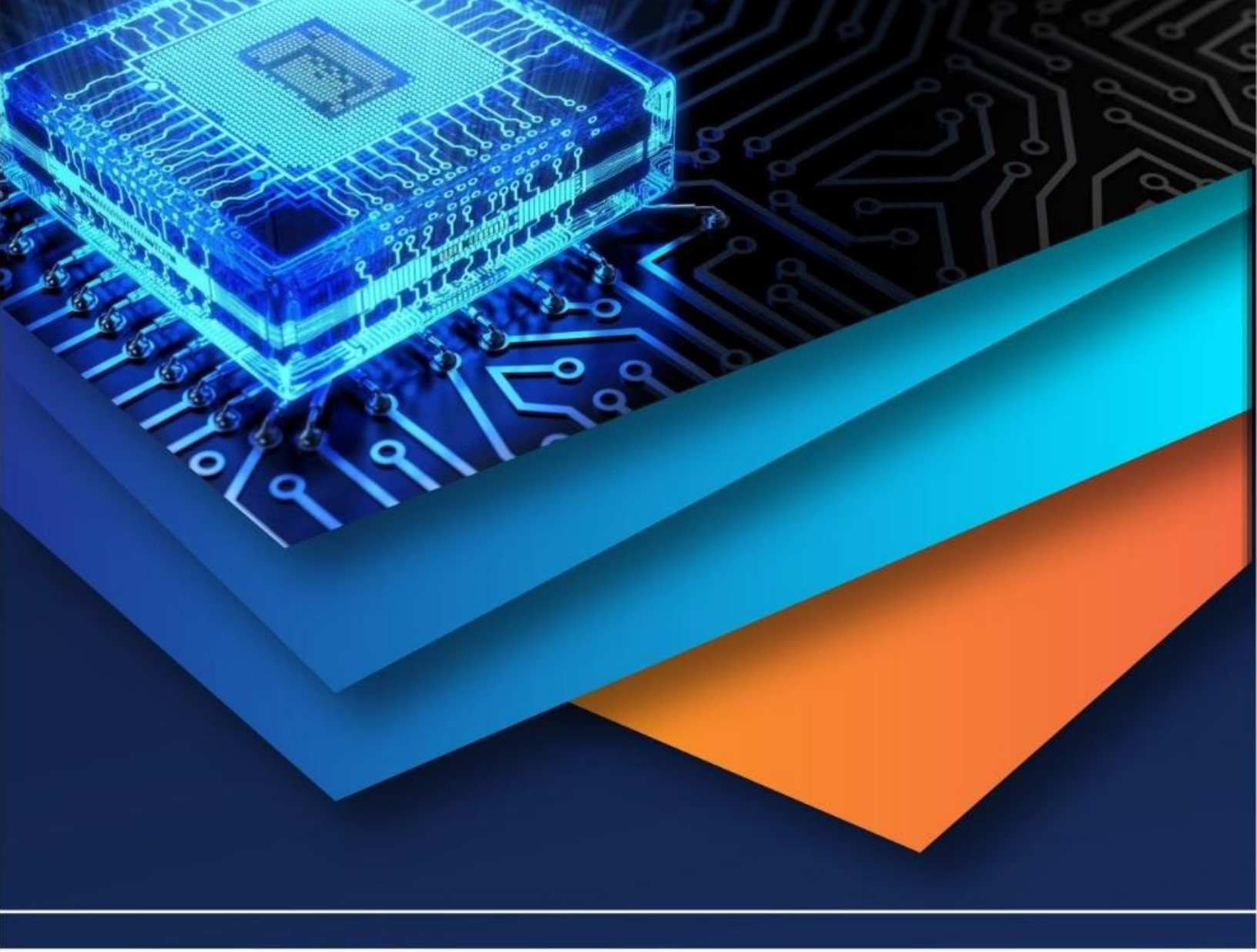
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