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Potential of Water Hyacinth (*Eichhornia crassipes*) as Compost and its Effect on Soil and Plant Properties: A Review

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ABSTRACT

Water hyacinth, the devastating weed grows in water bodies either naturally or as a result of human interference, is considered as threat to environment due to its negative effects on aquatic ecosystems. To alleviate its negative impact utilization of those become as better mean in recent decades. As such, water hyacinth is known to has potential to be utilized as nutrient source *via* composting, all most all types of composting techniques are applicable in preparation of compost from water hyacinth. Being an organic source, water hyacinth helps build up soil organic matter, in turn play vital role in the enrichment of the soil physical, chemical and biological properties. Aggregation of soil particles, porosity, density, water holding capacity, nutrient availability, cation exchange capacity, pH, soil microorganism are the soil properties reported to improve with water hyacinth compost application. Moreover, water hyacinth compost seems to be far better than the animal manures in improvement of soil properties. As a result, water hyacinth compost shows magnificent effect of plant agronomic growth parameters such as germination percentage, number of leaves, leaf area index, plant height, length of shoot and root, root: shoot ratio, biomass content as well as yield parameters. However, utilization of water hyacinth has few challenges like difficulties in harvesting, chance for heavy metal accumulation, hardness during decomposition, less awareness. Properly managed water hyacinth compost would serve as an alternative for inorganic nutrient sources in future thus indirectly the threat caused by this aquatic weed on environmental would become minimum.

Key words: Compost, Growth attributes, Organic matter, Soil properties, Water hyacinth.

Water hyacinth is a free-floating perennial aquatic weed native to tropical and sub-tropical South America (Rodrigues *et al*. 2014). Even it is originated in the Amazon Basin and has now spread to over 80 countries (Jafari, 2010). It is abundantly present in almost all types of wetlands vary from small fish ponds to big riverine lakes. Water hyacinth has been recognized as the most harmful aquatic weed in the world due to its negative effects on people's livelihoods and wetland ecosystems (Wilson, 2005). Water hyacinth dramatically impacts water flow, blocks sunlight from reaching native aquatic plants and starves the water of oxygen, often smother aquatic life by deoxygenating the water and it reduces nutrients for young fish in sheltered bays (Sindhu *et al*. 2017). Water hyacinth also interferes with water treatment, irrigation and water supply (Opande *et al*. 2004). The plants also create a prime habitat for mosquitos and a species of snail, classically causes diseases. It has blocked supply intakes for the hydroelectric plant, interrupting electrical power for entire cities. The weed also interrupts local subsistence fishing, blocking access to the beaches. Therefore, the control of this devastating weed receives attention and many efforts have been made to control these weeds through chemical, physical and biological methods. However, control of the weed has met with little success (Abdelsabour, 2010), in turn a need for an alternative mean of its control arouse. So that, rather than destruction make them useful was sought as better mean of control.

Since water hyacinth is being an organic manure, its effects in combating soil quality issues is well addressed. Water hyacinth helps to combat organic matter decline and soil erosion (Lickacz and Penny, 2001). Hence, water hyacinth is well known for its potential as nutrient replenisher either as green manure or compost. Water hyacinth is increasingly being used as a nutrient supplier as composted material (Malik, 2007). From the literature, it is clear that water hyacinth has potential to prepare compost by means of almost all the composting techniques and serve as a mean in soil fertility improvement. Composting of biodegradable water hyacinth puts back the nutrients into the soil through recycling them and helps to optimize nutrient management. Bacteria, actinomycetes, streptomycetes and fungi are among the mesophilic, thermo-tolerant microorganisms that

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have been found in composting of various waste materials (Hassen *et al*. 2001; Ryckeboer *et al*. 2003). It is capable of accumulating very high concentration of primary macro nutrients N, P and K (Balasubramanian, 2011) and could serve as source of these nutrients in fertility management upon decomposition (Kwabiah *et al*. 2003; Wasonga, 2008). Furthermore, water hyacinth has a high potential to supply nitrogen as it can store up to 3.2% in its dry mass and it generally has a carbon to nitrogen ratio (C/N) of around 8 to 15 (Khan and Sarwar, 2002; Gunnarsson and Petersen, 2007). Water hyacinth has not only found effective in soil fertility enhancement, it improves soil properties and health in turn enhances crop yield when applied as green manure or compost (Woomer *et al.* 2000; Gupta *et al.* 2004). In this review we briefly discuss the potential of water hyacinth as composting material and its effect on plant and soil. This would be utilized in future researches where control of water hyacinth till being a problem and composting is not practiced also it will be valuable teaching tool in the world of academia for control measures of water hyacinth.

Classification and morphology of water hyacinth

Water hyacinth is a free-floating perennial hydrophyte. It is a highly competitive plant that is capable of rapid growth and spread so that is called "menace and nuisance" to the ecosystems. The classification of water hyacinth follows as below:

Division: Spermatophyta
Sub-division: Angiospermae
Class: Monocotyledonae
Series: Coronariae
Family: Pontederiaceae
Genus: Eichhornia
Species: *E. crassipes* (Mart.) Solms

Morphological description

The leaves are broad, thick, glossy and ovate and float above the water surface (Fig 1). They have long, spongy and bulbous stalks. The feathery, freely hanging roots are purple-black. It tolerates annual temperatures ranging from 28-30°C (Burton *et al.* 2010) and its pH tolerance is estimated at 5.0 to 7.5. The 'beautiful blue devil' water hyacinth, grows rapidly as a dense green mat over stagnant water bodies such as lakes, streams, ponds, waterways, ditches and backwaters and is recognized by its lavender flowers and shinning bright leaves.

Water hyacinth as compost and its effect on soil properties

Composting is a natural process which involves the aerobic biological decomposition of organic matter from the biodegradable wastes using microbes under controlled conditions, resulting a final product containing stabilized carbon, nitrogen and other nutrients in the organic fraction, the stability depending on the compost maturity (Singh and Sharma, 2002; Chang and Chen, 2010). Similar to other organic manures, water hyacinth has potential to prepare compost with different methods (Table 1). The water hyacinth compost was found better than the town compost and farm yard manure in terms of nutrient contents such as N, P_2O_5, K_2O and C: N, it is four times richer than farm yard manure (Basak, 1948). Table 2 presents the nutritional composition of water hyacinth-based compost. Hence, the quality of compost may vary with raw materials, composting conditions (temperature, moisture and aeration), climate, method of composting *etc* (Table 1). Easily decomposable water hyacinth compost contributes buildup of organic matter in the soil and thereby affects soil physical as well as chemical parameters like the other organic composts. Balasubramanian *et al*. (2013) reported that the soil organic matter ranged from 0.64-3.57% in soil mulched with water hyacinth throughout cropping period irrespective of soil depth and days. Organic matter in the form of water hyacinth-based compost influences soil physical properties inclusive of aggregate formation, porosity, bulk density, water holding capacity, cation exchange capacity.

Response on soil aggregation

It is simply known as process of sticking of primary soil particles to each other more tenaciously than adjacent particles. Organic matter favours aggregation in soil as they tend to release gum like materials during decomposition process which helps in binding of particles. Water hyacinth as being an organic matter, addition of it into the soil enhances aggregate formation, primarily of state as well as degree of aggregation that varies with application rate.

Fig 1: Water hyacinth in natural water bodies.

Table 1: Comparison of water hyacinth composting methods.

Aspects	Composting methods				
	Heap	Aerobic pile	Pit	Vermicompost	Anaerobic
Raw materials	Water hyacinth, cow dung and straw OR Water hyacinth and soil	Water hyacinth and farm manures (cattle manure/ poultry manure) or Water hyacinth and molasses or Water hyacinth and effective microorganism (EM) solution (*Photosynthetic bacteria, Lactic acid bacteria, Saccharomyces cerevisae, Rhodo pseudomonas* spp and *Lactobacillus plantarium*)	Water hyacinth, Cow dung	Air dried water hyacinth, animal manures (Cow dung/ poultry manure) and earth worms OR Water hyacinth, paddy straw and earth worms	Water hyacinth
Maturity	12 weeks	6 weeks	16-18 weeks	6-12 weeks	8 weeks
Physicalcharacters	NA	NA	Black in colour, granular and fibrous with pleasant earthy smell	Dark grey to black, non- granular form, absence of foul odour	NA
Chemicalcharacters	N-2.05% P_2O_5-1.1% K_2O-2.5% C/N-13%	pH-7.6-8.3, 6.4; EC-7.1 TOC-8.6-16.1%, 44.8% Total phosphouous-0.36-1.36% Total organic nitrogen-1.36-2.21% C/N-25.2, 5.3-7.6P-2.3 g/kg K-12.9 g/kg; Ca^{2+}-0.46-0.84%; Mg^{2+}-0.15-0.18%	pH-7.3EC-1.24 ds/m Organic C-30.6% C: N-13.29 N-1.14%, 23.03 g/kg P-0.56%,84.9 mg/kg K-1.02%, 8.9 g/kg Mg-85.7 g/kg; Ca-37.2 g/kg	pH-8.50; EC-(dS/m)-5.63 OC- 24.54%; N -2.40% P-0.93% K -0.54%	C-9% N-1.13% C: N-8
Pros and Cons	Waive off the expenses in digging pit; Encourage draining of excess water Encourage evaporation of overabundance wetness	Loss of nutrients is less Short maturity period	Hard to have dry pit Fertilizer charged pits are powerless to holding outside water to delay deterioration and cause leaching of dissolvable supplements.	Quick conversion of organic material and production of stable non-toxic material with great structure doesn't execute weed seeds. Produces unsafe greenhouse gases. Leachate may spread plant pathogens.	Easy and less labour intensive
Reference	Balasubramanian *et al.* (2013); Bates and Hentges (1976); Osoro *et al.* (2014)	Beesigamukama *et al.* (2018); Dhal (2012); Mashavira *et al.* (2015)	Abdalla and Elballah (2015); Mathur *et al.* (2016); Oroka (2013)	Balasubramanian *et al.* (2013); Nasrin *et al.* (2019)	Khan and Sarwar, (2002)

NA-Not available.

Table 2: Nutritional composition of Water hyacinth-based composts.

Nutrition composition	Water hyacinth compost
TON (%)	1.36
TOC (%)	10-12
Total P (%)	0.028-0.38
pH	7.6-8.4
K (%)	1.1
C: N	7.6-9.3

Modified from (Naluyange, 2014) (Beesigamukama, 2018).
TON= Total organic nitrogen, TOC= Total organic carbon.

Higher organic matter with increasing amount of water hyacinth higher the state and degree of aggregation (Martin *et al*., 1955). Degree of aggregation was 27% higher than control when 1000 g of water hyacinth was used per pot in sandy loam soil (Khan and Sarwar, 2002). Hence, Rashid and Iftekhar (1992) additionally detailed that the degree of aggregation of soil expanded because of water hyacinth fertilizer.

Response on soil porosity and bulk density

Greater amount of organic matter deposition through water hyacinth-based compost improves aggregation process between soil primary particles into microaggregates through cementing agents (Polysaccharide gums) produced by soil bacteria upon the decomposition of added organic matter and further into macroaggregates by growth of fungal and actinomycete hyphae growing over the soil particles. All these aggregation process increase the total porosity in soil. As bulk density is inversely related to total porosity water hyacinth-based compost decreases bulk density in soils. The aggregation processes may have reduced soil bulk density and increased porosity with the soil having greater capacity for water retention and transmission (Goldhamer *et al*. 1994; Sultani *et al*. 2007). An increase in total porosity and corresponding decrease in bulk density than untreated plots were noted by (Oroka, 2013) in sole cassava and cassava-groundnut intercrop with application of vermicompost prepared from mixture water hyacinth and farm manure. Wanas (2006) observed 15% and 12.3% reduction in soil bulk density under shallow and deep ploughing respectively using water hyacinth compost when compared to control without organic amendments. Average bulk density values were 1.20 and 1.22 gm^{-3} for shallow and deep ploughing depths respectively. The study further noted increased total porosity of 12.41% and 10.49% for the same ploughing depths. The decline in soil bulk density with a related expansion in porosity under water hyacinth-based manures might be because of more significant measure of organic matter deposition (Haynes, 2000; Agbede *et al*. 2008).

Response on soil water holding capacity

Water hyacinth compost improves water holding capacity of soil in two ways. Firstly, water hyacinth as direct organic particles improve water holding capacity through their higher surface area and potential for adsorption of water molecules. Secondly, by influencing soil physical properties especially porosity and bulk density improve water holding capacity (Rashid and Iftekhar, 1992; Khan and Sarwar, 2002). As water hyacinth compost favours aggregation, porosity get increased either within the aggregates (micro pores) or between the aggregates (macro pores). With greater amount of micro pores water holding capacity increases. Water holding capacity of sandy loam soil increased from 8.21 to 10.16% with addition of 1000 g of water hyacinth compost (Khan and Sarwar, 2002). Similarly, Vidya and Girish (2014) also reported an increase in water holding capacity from 52.04 to 57.31 when garden soil is mixed with equal proportion of water hyacinth compost.

Response on soil cation exchange capacity and pH

Cation exchange capacity (CEC) is the total capacity of a soil to hold exchangeable cations. Compost prepared from water hyacinth has marked effect on cation exchange capacity of soil due to buildup of organic matter from water hyacinth compost. Organic matter components of soil have negatively charged surfaces onto which exchangeable cations are adsorbed. With decomposition of compost, the exchangeable cation nutrients get released and become available for exchange with colloidal surface.

Cation exchange capacity was higher in water hyacinth compost treated sandy loam soil than the untreated soil and higher water hyacinth content higher cation exchange capacity (Khan and Sarwar, 2002). Abdalla and Elballah (2015) reported an increase in cation exchange capacity from 22.95 to 23.78 at a depth of 0-30 cm. As exchangeable basic cations are exchanged and get adsorbed to organic matter and soil surfaces, acidic cations are released to soil solution and soil become acidic, receives less pH values. Abdalla and Elballah (2015) reported a decline in pH. In vice versa an increase in pH also was observed with addition of water hyacinth (Khan and Sarwar, 2002; Vidya and Girish, 2014). This might be due to precipitation of some cations, depletion of carbon source as composting proceeds for bacterial and fungal breakdown of recalcitrant materials of water hyacinth.

Response on soil mineral nutrients

Application of water hyacinth increase the mineral nutrients content in the soil as these nutrients ae considerably high in fresh water hyacinth. When compost prepared from this nutrient rich organic matter these nutrients get released into the soil upon decomposition process and become available for plant uptake. Comparatively higher total nitrogen and available phosphorous were recorded when soil is mulched with water hyacinth compost that control plots (Balasubramanian *et al*. 2013). Availability of nutrients vary with soil depth, times of application, decomposition and mineralization rate *etc*. With respect to nitrogen, water hyacinth compost application increased nitrate nitrogen (NO^{3-} N), ammonium nitrogen (NH^{4+} N) and total mineral nitrogen before sowing first main crop and even after harvesting of the crop as well and it was found to be two folds higher than untreated plots (Abdalla and Elballah, 2015). Further, they found that compost made from water hyacinth applied at 10 tons/hectare increased the mineral nutrients such as Ca, Mg, Na, K, P, total mineral nitrogen.

Moreover, Table 3 shows the effects of widely applied animal manures like cow dung and poultry manure along with water hyacinth manure compare to control on key soil properties. It reveals that, in overall, organic manures regardless of type improves soil properties. Of which water hyacinth-based manures found to be better than the animal manures as it has greater effect on soil properties referring to organic carbon, pH, CEC and primary soil nutrients (N, P and K). This might be due to inherent composition of water hyacinth. Hence, the effects vary with application rate and soil texture.

Effects of water hyacinth compost on plant growth

Water hyacinth-based compost application influences several growth parameters. Germination percentage, number of leaves, leaf area index, plant height, length of shoot and root, root: shoot ratio, biomass content, collar root diameter are some example for the growth attributes. In general, from the experiments it has been found that compost application increases the mean values of above-mentioned attributes either significantly or non-significantly than control. It's because of the availability of essential mineral nutrients required for plant growth and development. Nitrogen and phosphorous are the primary elements needed by plants. Phosphorus is important in root growth and development and therefore nutrient uptake; while nitrogen is important in chlorophyll formation for photosynthesis and protein formation hence fast growth (Hawkesford *et al*. 2012). These nutrients get released through mineralization process of organic matter content which improves moisture retention capacity of soil as well and thereby with improved dissolution of those released nutrients become readily available for plant uptake. Further, higher microbes in compost improves soil aeration and enhance uptake of dissolved nutrients by the roots and better growth and development of crops (Olupot, 2004). Effects of water hyacinth compost on growth parameters are indicated in the Table 4. These effects vary with rate of compost application; higher application rate higher the growth attributes, co-composting with other materials, stage of crop, soil condition. As compost releases nutrients slowly but steadily compare to inorganic fertilizers, effect of compost on growth attributes can be seen at later stages of growth rather than early stages. For example, 3.35 leaf area index was recorded in maize at 10th week by Beesigamukama *et al*. (2018) while it is 2.19 only at 6th weeks when water hyacinth compost applied. Higher shoot dry weight and plant height of 4.24 g and 26.17 cm respectively were observed 45 days after emergence in maize than that of 0.73 g and 15.57 cm respectively at 15th day with application of water hyacinth compost prepared with cattle manure and these were comparatively less when the compost is co-composted with effective microorganism (0.68 g and 16.32 cm). Though, compost application has positive impacts for many of the growth attributes, negative impacts also possible especially on number of days to maturity. Mashavira *et al*. (2015) mentioned that water hyacinth compost applied at a rate of 74.1 t ha^{-1} delays the maturity of tomato fruits as increased N supply increases plant growth and promotes vegetative growth at the expense of fruiting and maturing (Azam, 1985).

Effects of water hyacinth compost on yield

Application of water hyacinth has magnificent effect on yield of various crops. Several studies indicated that yield components like panicles/pot, 100 seed weight were significantly increased with application of water hyacinth compost either alone or fortified with nutrient rich locally available sources. Khan and Sarwar, 2002 notified an increase in yield of rice from 19.7% to 22.3 with application of water hyacinth compost at a rate of 1000 g per pot. Osoro *et al*. (2014) stated that weight of 100 seeds of common bean ranged from 41.5-50.2 in three farmers' fields that lie within the Lake Victoria Basin where no history of inorganic fertilizers application in the past six planting seasons with application of compost fortified with cattle manure. Furthermore, an average yield of 68 t/ha was recorded in tomato at a rate of 74.1 t/ha water hyacinth compost

Table 3: Effect of organic manures on soil properties.

Organic manures	Application rate	Soil texture	Organic carbon	N	P	K	pH	CEC	Reference
Water hyacinth compost	0.25 g/kg	NA	12.5%↑	NA	116.6%↑	85.71%↑	6.70%↑	NA	Muktamar *et al.* (2016)
Water Hyacinth compost	50 g/kg	Sandy Loam	73.46% ↑	41.75% ↓	NA	NA	0.80% ↑	47.97% ↑	Khan and Sarwar (2002)
Cattle manure	20 g/kg	Sandy Clay Loam	35.39% ↓	25% ↑	4.83% ↑	73.68% ↑	2.75% ↑	17.81% ↑	Ewulo (2005)
Poultry manure	20 g/kg	Sandy Clay Loam	46.54% ↑	45.45% ↑	5.625% ↑	87.5% ↑	5.66% ↑	20.83% ↑	Ewulo (2005)
Water hyacinth fertilizer	0.45 g/kg	NA	28% ↑	169.23% ↑	99% ↑	133.3% ↑	12.50% ↑	107.55% ↑	Gashamura (2009)

NA- Not available, ↑- increase, ↓- decrease.

Table 4: Effects of water hyacinth compost on physical growth parameters.

Growth attributes	Test crop	Dose of compost	Percentage increase compare to control	Reference
Germination percentage	Wheat	Soil : Compost 1:1	144.4	Vidya and Girish, (2014)
	Black gram	1:1	6.3	Sahana Sonter *et al.* (2018)
No of leaves	Okra	5 tons/ha	56.8	Lekshmi and Viveka, (2011)
Shoot length (cm)	Wheat	Soil : Compost 1:1	17.7	Vidya and Girish, (2014)
	Okra	5 tons/ha	40.4	Lekshmi and Viveka, (2011)
	Black gram	1:1	16.4	Sahana Sonter *et al.* (2018)
Root length (cm)	Wheat	1:1	36.2	Vidya and Girish, (2014)
Plant height (cm)	Tomato	74.1 tons/ha	63.2	Mashavira *et al.* (2015)
	Black gram	Soil : Compost 1:1	16.4	Sahana Sonter *et al.* (2018)
Root/shoot ratio (cm)	Wheat	1:1	15.7	Vidya and Girish, (2014)
Biomass	Wheat	1:1	205.5	Vidya and Girish, (2014)
	Black gram	1:1	22	Sahana Sonter *et al.* (2018)
Shoot dry weight (g)	Okra	5 tons/ha	56	Lekshmi and Viveka, (2011)
	Common bean	5000 kg/ha	105.6	Osoro *et al.* (2014)
	Maize	5000 kg/ha	161.1	Osoro *et al.* (2014)
Root dry weight	Okra	5 tons/ha	116	Lekshmi and Viveka, (2011)
	Common bean	5000 kg/ha	91.8	Osoro *et al.* (2014)
	Maize	5000 kg/ha	96.1	Osoro *et al.* (2014)

application by Mashavira *et al*. (2015). The higher yield associated with water hyacinth compost might be due to the greater availability of nutrients especially K which is essential in water regulation in the plant and increases physical and physiological components of plant such as leaf area index, chlorophyll content. Potassium is also a key component in enzymic activities, carbohydrate metabolism and translocation, nitrogen metabolism and protein synthesis; therefore, it increases production and distribution of photosynthates leading to higher yields. Increasing K content is believed to improve the yield of tomato (fruit) crops (Hartz, 2001) as it is responsible for tomato growth vigor and it stimulates early flowering and fruit setting thereby increasing the number of tomato fruits per plant and thus increasing yield. These findings clearly imply that water hyacinth compost has greater effect on yield of all categories of crops inclusive of cereals, legumes and vegetables as well.

Challenges in utilization of water hyacinth

Even though compost making is a possible mean for controlling the aggressive growth of water hyacinth in water bodies and application of this organic manure results several benefits in soil properties, but in practical this mean of water hyacinth control has some challenges. Longer time consumption, difficulties in water hyacinth harvesting, higher labour cost, chances for accumulation of heavy metals in plant tissues, less awareness and less skilled personals involvement are some of the mentionable. Here, the possible means to minimize these challenges are discussed.

Collection of water hyacinth for its utilization is the foremost challenge. In most developing countries water hyacinth harvesting is done manually in which aquatic weeds are removed from the water surface with the help of hands Therefore, manual reaping is labor-intensive work, with high energy and low proficiency and inefficient in huge lakes or water bodies. In addition, it consumes more time (Cerveira Junior and Carvalho *et al*. 2019) and may cause injuries to human with the aquatic fauna. These drawbacks can be minimized with mechanical harvesting for which mechanical mowers, destroyer boats, mechanized dredgers, weed harvester tractors and crusher boats are used to collect the weeds from water bodies. However, the initial capital cost is relatively high in this method of harvesting.

Water hyacinth being a plant biomass is primarily composed of three constituents such as lignin, cellulose and hemicellulose that are hardly available for microorganisms during decomposition of organic manure. The lignocellulose is the major organic compound that restrict the rate of composting of agricultural and forestry waste, among which the lignin acts as a major supplier of speed limiting compound (Patel *et al*. 1993). Therefore, to attain good quality water hyacinth compost in a shorter time period, it is necessary to speed up the degradation of lignin, cellulose and hemicelluloses during the composting process. Inoculation of water hyacinth with external lignin degrader, use of rotary drum for composting are available possible means to fasten the degradation of water hyacinth. Rotary drum composting provides high-rate composting due to appropriate mixing of composting materials and higher thermophilic temperature (Singh and Kalamdhad *et al*. 2014).

Water hyacinth is a well-known cleaner of pollutants, especially effective for removal of heavy metals. Therefore, a question remains that there are chances for accumulation of absorbed heavy metals into plant tissues when use water hyacinth for compost making. In this context, rate of application influences accumulation of heavy metals. Mashavira *et al*. (2015) reported that accumulation of heavy metals (Pb, Cu and Zn) was less than Codex Alimentarious Commission permissible level and recommended application of water hyacinth compost at a rate of 74 t/ha for increased tomato yield without heavy metal toxicity to consumers. However, in general water hyacinth roots absorb more heavy metals than the shoots and these roots and rhizomes can be excluded in compost making as frontline prevention of minimizing accumulation of heavy metals. On the other hand, powdered water hyacinth can be made into slurry and allowed for fermentation for a period of three months to reduce the heavy metal concentration (So *et al*. 2003; Sanni and Adesina, 2012). Hence, sullied rhizomes and roots of water hyacinth can be dried into ash and heavy metals could be separated and reused (Jadia, 2009).

Loses of nutrients primarily nitrogen, potassium through leaching (Guo *et al*. 2012; Goyal *et al*. 2005, Masaka and Ndhlovu, 2007) and denitrification (Prasad *et al*. 2013) during composting is another challenge associated with. The loss of nutrient delays composting maturity (Osoro *et al*. 2014; Lata and Veenapani, 2011; Seoudi, 2013) and decreases the quality of compost produced. Therefore, composting water hyacinth with materials like poultry manure, cattle manure, molasses and effective microorganisms can also help to reduce nutrient losses as well as hasten the decomposition process (Sylvia *et al*. 2005).

SUMMARY AND FUTURE PROSPECTS

Water hyacinth is considered as the world's worst aquatic weed as it causes environmental degradation due to their vigorous growth and unique characteristics. Increased agricultural runoff into water bodies has resulted in a rise in nutrient concentrations, causing turbidity and a drop in dissolved oxygen. This has resulted in algae blooms, waterweed infestations, fish mortality and water-borne infections. The usage of water hyacinth compost reduces the amount of chemical fertilizers and organic fertilizers required, lowering both costs and pollution. To eradicate its negative impact on ecosystems, make use of them is found as best alternative. Water hyacinth has a great potential in soil fertility management as a slow release organic fertilizer via composting. Water hyacinth compost as having greater amount of organic matter it plays significant role in improvement of soil physical, chemical and biological properties which in turn make available nutrients that are required for plant growth and development hence leads to considerably higher growth parameters and yields. Findings got so far on effects of water hyacinth compost are limited to mainly sandy loam soil textures and annuals. Therefore, in future, studies can be expanded to explore the effects of water hyacinth in other textured soils as well as perennials. Hence, though water hyacinth is a good source of alternative for inorganic fertilizers in soil nutrient management no any studies have done yet on the potential of water hyacinth to be utilized as liquid fertilizer and its effect on physical and physiological parameters of crops and soil properties. So that, in future, with the knowledge and idea obtained from this review younger generation may focus this scope as well. Moreover people are less aware about potential of water hyacinth as nutrient source and the gap can be reduced with awareness programmes.

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