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Water Hyacinth a Sustainable Source of Feed, Manure and Industrial Products: A Review

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ABSTRACT

Water hyacinth is a perennial aquatic weed that can be utilized effectively rather than spending energy in eradicating them. It is the source of N, P, K which is essential for the growth of plants. In India, locally available horticulture wastes and grasses are fed to cattle predominantly. Water hyacinth in the dried form or as ensilage may be given as cattle feed due to high protein content in it. The amino acid profile of water hyacinth makes it suitable to be used as pig feed. When Water hyacinth is used as poultry feed, it increases the egg laying ratio and boosts cell mediated immunity of the poultry. Water hyacinth can be used as an alternative of soy bean meal in fish feed which reduces the feed cost. Water hyacinth is also used to make paper, cardboards, disposable cups, plates and variety of products for human use. Water hyacinth thus becoming potential raw material for making valuable products to meet the sustainable solution for water hyacinth management.

Key words: Cattle feed, Fertilizer, Fish feed, Poultry feed, Valuable products, Water hyacinth.

Water hyacinth (*Eichhornia crassipes*) is a free floating perennial aquatic plant belonging to the family Pontederiaceae. It is found in fresh water ecosystems and spread on the surface of rivers, lakes, canals and ponds and may root in the mud of shallow waters. It is a fast-growing invasive aquatic plant that often covers water bodies. Plant height ranges from a few inches to a meter. The plant's reproduction takes place at a faster rate under suitable conditions (Herfjord *et al.* 1994). It is an invasive species, which invades freshwater habitats and is listed alongside several worst weeds (Center *et al.* 1999). In 2016, the EU has banned the sale or movement of water hyacinth within their sphere of influence by placing it under EU's Invasive Alien Species Regulation. Water hyacinth is extremely difficult to eradicate by physical, chemical and biological means and a substantial amount of money and energy is spent on their control annually throughout the world. Though this weed is considered as a menace, it can be effectively utilized in many beneficial ways. In this review some of the important uses of "water hyacinth" has been presented (Fig 1).

Distribution

Water hyacinth had its origin from Amazonia and spread naturally throughout South America. It had been introduced as a decorative species into the USA, South East Asia and South Africa in the late 19th century and is now naturalized in most tropical and subtropical areas. The plant can double within 6-15 days (Hasan *et al*., 2009). In India, water hyacinth was first introduced in Bengal, for its beautiful flowers and leaf shapes, but turned out to be an invasive weed, depleting oxygen from water bodies and resulted in devastation of fish population. It was called "Blue Devil" in Bengal and "Bengal Terror" elsewhere in India. It was also known as "German weed" in Bangladesh.

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Nutritional attributes of water hyacinth

Fresh water hyacinth features a very low dry matter content, which makes the plant extremely bulky, leading to low intakes of nutrients. The composition of the plant is extremely variable. The protein and the mineral content are highly dependent on the composition of the water where the plants are grown.

Nutritional composition of water hyacinth as fertilizer

Water hyacinth liquid manure has significantly high N (3.72%) and P(2.86%) contents indicating its suitability as a macronutrient fertilizer. Water hyacinth fertilizer comprises 95% water and 5% dry matter of which 50% is silica, 30% potassium, 15% nitrogen and 5% protein (Makhanu, 1997).

The proximate composition leaf extract of *Eichhornia* on % wet basis: Moisture content - 90.2; Nitrogen content - 1.03; P content - 0.42; K content - 1.81; Ca content - 0.02. According to Argupis (1953), the nutrient composition of water hyacinth as silage comprises of crude protein 0.9%, Nitrogen free extract 3.9%, Crude fats (ether extract) 0.4%, crude fiber 2.2%, ash 2.0%, calcium 0.3% and potassium 0.1%.

Cattle feed

Water hyacinth is usually fed to ruminants as fresh forage, hay or silage. High level of ensilaged water hyacinth in cattle diets improved crude protein intake and digestibility of nutrients. Cattle fed fresh water hyacinth showed abnormal rumen distension and a gradual increase of rice straw intakes over time. An extended adaptation period to fresh water hyacinth and an inclusion level of less than 30% diet dry matter are suggested. When fed alone for extended period, freshwater hyacinth cannot maintain body weight and leads to cases of malnutrition, renal failure and death.

Water hyacinth as a substitute for animal feed

Utilizing water hyacinth as a livestock feed is one of the better approaches out of many other ways of controlling the growth of this plant. Much research has been done to incorporate water hyacinth as a feed material for many classes of livestock. Livestock place an important role in sustaining livelihood, nutritional and environmental security and growth of Indian agricultural shortage of feed resources in India has been documented by various organization, but several locally available feed resources used for feeding milch animal are not considered. These include industrial byproducts, horticulture and vegetable waste, local grasses tree leaves, weeds and other non-conventional feed resources. Many studies have estimated water hyacinth as a feed material for cattle (Parashar *et al*., 1999; Thu, 2011), goats (Kibria *et al*., 1990; Hira *et al*., 2002) and sheep (Baldwin *et al*., 1975; Abou-Raya *et al*., 1980). Water hyacinth is often fed in fresh, ensiled or dried form and many other processes including cooking and fermentation have also been tried. It is suggested that water hyacinth growing in industrial wastewater and in waters surrounding mining areas may be unsafe to utilize as feed. Water hyacinths gain higher protein content when they are grown in fishponds and can be fed to fish and pigs in different forms. Fish and pig manures can be used to fertilize fishponds and they supply nutrients to water hyacinth.

Pig feed

Water hyacinth foliage usually fresh used as a supplement for pigs. Water hyacinth is additionally boiled with plant or animal by-products to make a complete pig diet, though this might not be very practical for pig farmers.



Fig 1: Water Hyacinth.

Water hyacinth is often a good protein source in pig diets and its amino-acid profile is well-balanced. The utilization of water hyacinth as pig feed is hindered by its bulkiness, high fiber content and low palatability. The presence of hydrolysable and condensed tannins and the high fiber content tend to decrease the activity of digestive enzymes in the pigs and *in vitro* protein digestibility is only 40%.

Poultry feed

It is recommended to use dried and ground water hyacinth in poultry diets. Water hyacinth can act as a source of pigments for poultry. Geese and goslings have been recommended as a way regulate infestation by water hyacinth in waterways and canals cited by Hugo, 1995. Lu *et al*., (2008) reported that the ducks fed with water hyacinth showed the 5.86% higher average daily feed intake as well as 9.79% the higher egg-laying ratio. An incorporation level of 2.5% water hyacinth matter in broiler chicken diet is recommended, as it showed the highest final body weight as well as significant increase in the voluntary feed intake (VFI) and cell-mediated immunity (Dumaup and Ampode, 2020).

Fish feed

Water hyacinth is a potential ingredient in farm-mixed feeds for herbivorous or omnivorous freshwater fishes in simple production systems and where it is available at low cost. Water hyacinths are fed to fish either fresh, dried meal in pelleted diets, or composted as feed and fertilizer. It can be incorporated in fish feed as protein source with the partial replacement of fish meal. A diet consisting of 40% inclusion of water hyacinth could be used as a replacement for fish meal in diet formulation for common carp fry. A level up to 20% water hyacinth proteinin place of soybean protein in a diet for feeding Nile tilapia fingerlings is recommended. An incorporation level of 15%-25% water hyacinth meal supported the growth. The presence of high fibre content in water hyacinth yielded significant low weight gains and specific growth rates in African catfish fry fed with water hyacinth meal diet, when compared to soya bean meal diet. Therefore, water hyacinth leaf meal can be recommended for the replacement of fish meal. Otherwise, further processing is recommended to bring down the fibre content below 4.7%.

Studies showed that tilapia performed better with pelleted diets containing composted water hyacinth than with diets containing dried water hyacinth. The better performance might have been resulted due to lower levels of crude fibre in the composted diets.

Water hyacinth as a substitute for paper pulp

A growth in paper demand, along with a decline in the supply of fibres from the world's forests is forcing the pulp and paper industry to find alternative sources of fibres that are both technical and economically viable. Global paper and paperboard production has increased from 371 million tons

in 2009 to 400 million tons in 2015 (FAO, 2017). The global shortage of fibrous resources has aroused great interest in the use of non-conventional fibrous raw materials (weeds, shrubs and non-timber), which can be used to obtain cellulose for paper production.

Water hyacinth as fertilizer

Water hyacinth is employed as fertilizer, as a result of its high nutritional contents. They result in high production, and since these organic materials are simply decomposed, they do not influence fish. Organic fertilizers are soil amendments containing the minimum contents of nitrogen, phosphate and potassium (NPK) that's derived from derivatives of an organism. The NPK in organic fertilizers should return exclusively from organic reserves that are inherently high in NPK and not from crude or ammonia-derived fertilizers like nitrate or artificial organic compound. The application of organic fertilizers has been shown to possess positive impacts on soil fertility, soil physical properties and consequently crop yield.

Liquid fertilizer

Now a days, liquid fertilizers have well replaced traditional, standard, agricultural field-dominated fertilizers (commonly offered in granular form) have been used in sport-fish ponds within the South Japanese. The presence of low amount of nutrients like phosphorus and inorganic gas within the root of genus Eichhornia makes it appropriate material for creating liquid fertilizers.

Preparation of liquid fertilizer

Most used methodology for preparation of liquid fertilizers composting or fermentation.

Procedure:

- Take whole aquatic plant plants.
- Cut into 2-3 cm (by employing a rotary chopper).
- Sun-dried on elevated platform (Moisture content of concerning twenty%).
- Compost is formed by intermixture dried associated freshly cut aquatic plant (With an initial pile wet content of 65-70%).
- Mixture is formed into a pile (of a pair of .5 × 2 × 1.3 m (l × b × h).
- Perforated bamboo poles are inserted for aeration.
- The mixture is turned often (to facilitate decomposition). The composting method can end at intervals of fifty days.

Mulch fertilizer

As a fertilizer, aquatic plant will be used on the land either as a manure or as compost. As a green manure it can be either tilled into the bottom or used as mulch. The plant is good for composting. When removing the plant from the water it can be left to dry for many days before being mixed with ash, soil and a few animal manures. Microorganism decomposition breaks down the fats, lipids, proteins, sugars and starches. The mixture can be left in piles to compost; the hotter climate of tropical countries accelerates the method and produces wealthy pathogen free compost which might be applied on to the soil. The compost will increase soil fertility and crop yield and customarily improves the standard of the soil. Gourab and Soumen (2008) confirmed, that organic manure offers way higher result than chemical fertilizer and its prices nothing, however solely labor.

Products made from water hyacinth

The products made from water hyacinth fibre have the advantage of the fibre tough and durable properties, which could last up to 3-5 years. It could be weaved into any form which is suitable to change according to the market trend. Currently, water hyacinth fibre has been applied to create various products such as coaster, slippers, basket, hat, fruit tray, furniture, handbag, and women purse. Tough yet flexible is known to be key properties of water hyacinth stem, which is the main material used to produce water hyacinth fibre. Thanks to those properties, water hyacinth fibre could be weaved into any form desired, with 3D weaving technique. Natural water hyacinth fibre come in beautiful golden-brown colour, yet both natural and chemical dyes can be added to create even more colourful artefacts. Water hyacinth fibre is also biodegradable. With a proper coating and care, water hyacinth products could live up to 3-5 years of use, however, water hyacinth fibre could be naturally disposed within a few months as well. Nowadays water hyacinth is used for decorative purposes and it plays main role in hand craft products like handbags, wallets, flower pots, fashion accessories, mats *etc*. Many creative and decorative home furnishing products are manufactured from water hyacinth stem (Fig 2).



Fig 2: Products made of water hyacinth fibre.

It is considered as waste plant, but it has many useful properties in textile, leaves are used to extract dyes and flowers are used in medicating the skin of horses. Water hyacinth is used for various purposes as such in fertilizers, paper making and handcraft products. Most of the products are done successfully by using water hyacinth plant. Paper making process is done with good result, but the fibre alone does not make a good paper, when it is blended with waste paper or jute the result is good. Water hyacinth fibre is extracted from water hyacinth stem part then additional chemical treatment is given to the fibre to improve the quality of the fibre.

CONCLUSION AND FUTURE RESEARCH

Since it is easily available and could be naturally disposed within a few months, water hyacinth has been utilized in several small cottage industries in countries like Philippines, Indonesia, and India for preparation of products such as paper, rope, basket, mats, shoes, sandals, bags, wallets, vases, *etc*. But these don't seem to be very successful to cut back infestations and the market for these products is much too small to have any impact on water hyacinth populations. As Water hyacinth fibre is also bio-degradable and the shelf life of water hyacinth products may range between 3 to 5 years. Therefore, the nutritional composition as well as the presence of toxic substances in water hyacinth mainly depends on, the water where they have grown. The toxicity of the feeds formulated from this weed should be investigated in order that it is safe to use as feed for the animals. Further research is also be needed to explore the chance of drug formulation from this weed. We must explore the possibilities of making disposable plates, cups, bags *etc*., Though the invasive nature of water hyacinth makes it an environmental challenge, it also has many productive uses. So, it shouldn't see as a menace but attempt to control their growth and utilize them for various useful purposes.

Conflict of interest: None.

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