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Investigation on Suitability and Safeness of Water hyacinth for Animal Feed, from Lake Ziway

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ABSTRACT: Water hyacinth is a free-floating aquatic plant native to the Amazon Basin in South America and the most dangerous and worst aquatic plant in the world including Ethiopia. The objective of the current study was to evaluate water hyacinth found in Lake Ziway for its suitability and safe as animal feed. Suitability of the water hyacinth was determined based on its nutrient content, while safety was determined based on the level of selected heavy metals, and pesticides. Three sites were selected for sampling purposively based on the types of land use and potential sources of water pollution around the Lake. Water hyacinth samples were collected from the selected sites and the level of selected heavy metals, 21 organochlorine, and 14 organophosphate pesticides were analyzed using atomic absorption spectrometry and Gas Chromatography-Mass Spectrometry (GC-MS), respectively. The proximate analysis in the water hyacinth were also determined using the standard method of analysis. The results obtained demonstrate that the level of heavy metals found the ranged from ND to9.0 mg/Kg for cadmium; ND to 30.44 mg/Kg for chromium; 118.1 to 518.8 mg/Kg for manganese; 6.78 to 57 mg/Kg for copper; 34.28 to 884.19 mg/Kg for iron; 2.84 to 37.02 mg/Kg for nickel ND to 21mg/kg for lead and 25.67 to 89.9 mg/Kg for zinc. All pesticides levels were below the limits established by European council regulation for plants used as animal feed which is <0.001mg/Kg. The proximate analysis of the water hyacinthsamples of the leaves parts was moisture content 9.32%, crude protein 18.03%, crude fat 1.42%, crude ash 17.04%, crude fiber 31.04% carbohydrate 22.30%and energy 174 Kcal. The result of the stem revealed the presence of 3.96 moisture content, 2.17% crude protein, 0.47% crude fat, 5.23% crude ash, 6.70% crude fiber, 81.47% carbohydrate, and 338.79 Kca energy. Based on the results of this study, water hyacinth in the Lake Ziway can be potentially used for animal feed.

Keywords/Phrases: Animal feed, Heavy metals, Nutritional value, Pesticides, Water hyacinth

INTRODUCTION

Water hyacinth is a fast-spreading aquatic weed that harms ecosystems and human benefits both internationally and in Ethiopia. The weeds' fastest growth, reproduction methods, and ability to adapt to a wide range of environmental conditions and nutrient conditions, its management was complicated by its extensive root system (Dechassa& Abate, 2020).The plant has caused considerable harm to its global distribution both on habitats and human livelihoods. Such negative impacts are extremely difficult for developing nations like Ethiopia. Ecosystem functions including physical structure, population composition, biogeochemical cycling, and hydrology can be altered by invasive aquatic vegetation (Bertness, 1984; Vitousek, 1990). Tourism activities are stuck and transportation of goods through the lake is no longer possible because propellers are hooked by the water hyacinth mats. It suffocates fish and another biodiversity by preventing the penetration of oxygen through its thick mats to the bottom of the water body. It acts as breeding grounds for mosquitoes, snakes, crocodiles, and vectors of *schistosomiasis*thereby causing diseases to the communities (Jenette, 2012).

Water hyacinth has a huge impact on the environment, human health, and economic development (Ashton *et al*., 1979; Ferna´ndez *et al*., 1989; Julien *et al*., 1996; Mailu, 2000; Villamagna and Murphy, 2010). Water hyacinth has an economic impact by reducing the fish number and quality, impeding streams and obstructing water transportation, jamming tunnels and turbines, reducing hydropower generation, as well as restricting irrigation canals, and reducing the

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scenic value of lakes and tourism. Water quality decline, water loss due to increased evapotranspiration, siltation, flooding, and aquatic life decline are the most significant environmental problems of water hyacinth (Mailu, 2000; Opande *et al.,* 2004; Ouma *et al.,* 2005). In Ethiopia, many researchstudies were done about water hyacinths. But the research mostly focuses on the effects and management techniques (Dechassa and Abate, 2020). The recent study on Lake Ziway examined only the concentration and human health risk assessment of organochlorine pesticides in edible fish species (Yohannes *et al.,* 2014). The results indicated that the consumption of fish is at little risk to human health at present. However, no other studies have been done on the evaluation of pesticides, heavy metals concentration and nutritional value in the water hyacinth. In addition, water hyacinth suitability for animal feed has not yet investigated. Hence, this study aimed to evaluate the level of heavy metal, pesticides, and nutrient in water hyacinth collected from Lake Ziway and assess its suitability for animal feed.

MATERIALS AND METHODS

Description of the Study Area

Lake Ziway is located in the northern part of the Rift Valley Basin. It covers a total surface area of 434 km^2 (Yohannes *et al*., 2014). In Lake Ziway there are five major islands such as Tulu Gudo, Gelila, Tedecha, Funduro and Debresina (Schoroder, 1984). The latitude and longitude of Lake Ziway are 7°52'–8°8'N and 38°40'–38°56'E respectively (Makin *et al.,* 1975). The elevation of Lake Ziway is 1636 meters above sea level (m.a.s.l). The two main feeder rivers, Meki and Ketar drain into the lake from the Eastern and Western highlands, respectively. The overflow from Lake Ziway flows downstream into the terminal Lake Abiyata (Musie *et al.,* 2020). The mean annual precipitation varies from 1200mm/year in the region across the rift floor with the high altitude to 700mm/year, approximately 900mm/year of annual precipitation over the entire basin.

Sampling

Water hyacinth samples were collected randomly from the inlet of the River at Meki River, around the Haile resort, Sher Ethiopia Company because of the potential sources of lake pollution. The samples were washed by the lake water to remove mud from the plants and then raised with distilled water before being cut and packed into nylon bags for transport to the laboratory.

Sample Preparation for Pesticides Residue Analysis

The acetate buffered QuEChERS sample preparation procedures for pesticide residues (AOAC Official Method 2007.01) were applied to all the samples. About 1 kilogram of water hyacinth was cut with a knife and 200 grams of subsample was homogenized with a probe blender. About 15 grams of homogenized water hyacinth sample were weighted with electronic balance and transferred to 50mL Teflon tube, and 15mL of 1% of Acetic acid, Acetonitrile, 1.5-gram anhydrous sodium acetate, and 6gram of anhydrous of magnesium sulfate (powder form >98% purity) was added and the sample was shaken with vortex for one minute. The sample was then centrifuged at 4000 rpm for 20minute and 4mL of the supernatant was transferred to a 15mL PTFE tube to which 150 mg magnesium sulfate and 50 mg PSA per ml were extracted were added. The extracted was shaken using a vortex for one minute and centrifuged at 4000 rpm again for 10 minutes. 3mL of the supernatant was filtered through a 0.45mm PTFE (13mmdiameter) was transferred to an auto-sampler.

Chemicals

Acetic acid, anhydrous sodium acetate, anhydrous magnesium sulfate, primary secondary amine, acetonitrile, graphitized carbon black, argon, hydrogen peroxide, nitric acid, water, deionized water, formic acid, pesticides standard chemicals purchased from Aldrich.

Apparatus

Vertical cutter, probe blender, Teflon tube, centrifuge, vortex, micropipette, electronic balance, vial, spatula, conical flask, filter paper, measuring cylinder, funnel, stainless steel scissor, syringe, 50m fluorinated ethylene propylene centrifuge tube, solvent dispenser, centrifuge tube, volumetric pipets, dropper, mortar, pestle, volumetric flask, test tube rack, well plate.

Sample Preparation for Heavy Metals Analysis

Water hyacinth samples were washed with tap and distilled water to ensure the elimination of dirt particles from the samples. The sample was cut separately into stem, root, and leaves with stainless steel, and these were dried on sheet paper to reduce extra moisture and then carefully dried in the oven at 70 for 24 h. 3gram of each dried part of the water hyacinth sample were weighted with electronic balance and chopped into pieces with pestle and mortar. 5mL of HNO3 (70%) and 1.5mL, $HClO_4$ 60%, and 4mL of H_2O_2 were added to 0.5g of each sample; the solution was digested with Kjeldahl apparatus (Gallenkamp, Germany) for 4 h until the fumes stopped, and the resulting solution has become clear. The digested samples were cooled at room temperature, then filtered through Whatman paper No. 42. The total filtrate was mixed and made the volume up to 50mL with deionized water. A blank was also prepared for every sample in the same way. The AAS system (ZEE-nit 7000, Japan) used was equipped with a flame and graphite furnace having a wavelength range of 185-900 nm and a detector photomultiplier of 185.0-600.0nm. The concentration of the stock solution used in AAS such as copper, lead, chromium, zinc, iron, nickel, cadmium and was 1000ppm for calibration curb.

Sample Preparation for Proximate Analysis

The water hyacinth was washed with clean water and then dried under sunlight for 5 days. The plant was divided in terms of stem and leaves and was dried in the oven at 100°C for 3 days. After dried the samples were introduced to Blender to change their power. All the water hyacinth samples in the powder form were subjected to analysis of moisture, crude protein, crude fat, crude ash, and crude fiber using different analytical methods. The analysis was carried out by the Association of Analytical Chemists (AOAC, 1999).

Determination of Crude Fiber

Both stem and leave crude fiber were determined by the method of SOP/7-2-C5. 1g of powdered water hyacinth sample was digested in 150mL of 1.3M of H_2SO_4 solution with bumping chips for 30min. The solution was filtered over the Buchner funnel using Whatman filter paper No. 42 and washed with hot water to remove the acid. The residue was also digested with150mL of 1.3M of NaOH for 30min, under the same conditions and the residue was washed with boiling water and acetone. The residue was dried in an oven at 105 for 8 hours and weighed, then transferred in a muffle furnace at 550℃ for 4 hours. In this action,

only ash was left of it. The crude fiber was calculated as follows

Percent crude fiber (%CF) = (W2-W3) X 100

Where, W1=weight of the sample (g)

W2 = weight crucible and residue after drying (g); and

W3= weight of crucible and residue after incineration (g)

Determination of Crude Protein

The nitrogen content of the water hyacinth stem and leaves are measured and multiplied by a factor of 6.25 to get crude protein. The fact that most protein contains 16 percent nitrogen accounts for this issue. The Kjeldahl method is used to determine crude protein. Digestion, distillation, and titration are all part of the process.

W_4=

$$(Vs - Vb) \times N \times 14.007 \text{ or } W4 = Vs \times N \times 14.007 \text{ if blank is not tested}$$

$$\% \text{ Nitrogen} = \frac{w4}{w1\ (in\ millgram)} \times 100$$

$$\% \text{ protein} = \% \text{nitrogen} \times F$$

Where F is a factor of protein that depends on the types of sample tested.

Determination of Crude Ash

Weight 2.5 g of powdered water hyacinth stem and leave and incinerated at 500 °C in a silica crucible on the hot plate until the smoke was stopped. Then burn with muffle furnace to remove the remaining organic matter at 550°C for 2hrs. The ash formed was white and free from carbon. It was cooled and weighed on an electronic balance.

$$\%\text{Ash} = \frac{\text{wt of cruccible+ash} - \text{wt of crucible}}{\text{wt of sample}}$$

Determination of Moisture Content

Accurately weigh 5 grams of powdered stem and leave water hyacinth with an electronic balance. Dry the water hyacinth sample with oven at 92°C for 6 hrs. Remove the crucible from the oven, cool in the desiccators for 30 minutes, and weigh. Dry for a further 1hour at 92 °C complete dryings, cool in desiccators, and take the weight again. Repeat the heating, cool, and weighing until a constant weight was achieved. For the 5 g powdered water hyacinth sample, the difference between the two successive weightingswas less than 2 mg.

$$\% \text{ moisture} = \frac{(w1-w2)}{(w1-w)} \times 100$$

Statistical Analysis

Statistical analysis of the data was carried out using one-way analysis variance (ANOVA) to assess significant variation in the mean concentration of heavy metals and nutritive value in the plant samples. ORIGIN PRO® 2015 software also was used for making Figures and calibration curves of heavy metals. All statistical analyses were done by SPSS version 26.0(IBM, USA) software.

RESULTS AND DISCUSSION

Heavy Metals Level in Water hyacinth

Concentration of Cadmium

The concentrations of cadmium found in water hyacinth collected from Lake Ziway are presented in Table 1. The results found in the analysis showed that the highest concentration of cadmium metal was in the root followed by the stem. It was observed that cadmium largely accumulated around the Sher Ethiopia sampling site (Table 1). It also observed that in around Haile resort the content of cadmium was much higher than from Meki River, especially in the root part of the samples. The concentrations of cadmium in the root at sampling sites of Sher Ethiopia Company, Haile Resort, and Meki River were 9, 3.75, and 1.57 mg/kg, respectively. Around Haile resort, the concentration of cadmium in the leaves part of the water hyacinth was not reported since they were below the detection limit. The levels of cadmium in the stem part of the samples from Sher Ethiopia, Haile Resort, and Meki River were 1.15 mg/Kg, 1.1 mg/Kg, and 0.9 mg/Kg, respectively.

Table 1: Concentration of Cadmium in water hyacinth in Lak Ziway mg.Kg^{-1} and maximum permissible limit in animal feeds.

Sampling site	Plants part		
	Root	Stem	Leave
Sher Ethiopia	9.0±0.0218	1.15±0.00081	1.19±0.0058
Around Haile Resort	3.75±0.0058	1.1±0.0122	ND
Meki River	1.57±0.00088	0.9±0.0204	2.1±0.00667
MPL 10			

Note: ND note detected

Source for MPL (NRC, 2005)

In the current study, the concentration of cadmium metal in the water hyacinth was lower than that found in previous studies. Matindi (2016) reported the concentration of cadmium in the water hyacinth from Lake Victoria of root 484 – 3361mg/Kg, stem 595 – 2136mg/ Kg, and leaves 408 – 1835 mg/Kg. Veschasit *et al.*, (2012) also reported the level of cadmium in the Ipomoea aquatic plants to root 0.95mg/Kg, stem 0.37mg/Kg and leave 0.30mg/Kg and similarly lower than the same plant obtained by Reddy (2014). However, the concentration of cadmium in the present study was found to be low range reported by Adigwe (2019). According to National Research Council (NRC, 2005), the maximum tolerable level for animal feed of cadmium is 10mg/Kg.

Concentration of Chromium

Table2 showed the concentration of chromium in the water hyacinth tissue was appreciable except for the leave parts of the samples which showed non-detectable values of the chromium metals. From Table 2, higher concentrations of chromium were registered around the Sher Ethiopia company sampling site from Lake Ziway. The concentration was 30.44 mg/Kg, 2.77 mg/Kg, and ND in root, stem, and leave, respectively. The content of chromium in the Haile resort root, stem, and leaves was 10.75 mg/Kg, 1.94mg/Kg, and ND, respectively. The concentrations of this metal also in the Meki River sampling site were 13.45 mg/Kg, 2.1 mg/Kg, and ND mg/Kg in root, stem, and leave part of the sample, respectively.

Table 2: Concentration of Chromium in water hyacinth in Lak Ziway mg.Kg^{-1} and maximum permissible limit in animal feeds.

Sampling site	Plants part		
	Root	Stem	Leave
Sher Ethiopia	30.44±0.017	2.77±0.0318	ND
Around Haile Resort	10.75±0.0203	1.94±0.0064	ND
Meki River	13.45±0.026	2.1±0.0031	ND
MPL 500			

Sources for MPL (NRC, 2005)
Note: ND note detected

The level of chromium in this study was higher in the root and stem parts of the samples than obtained by Adigwe (2019) and Woldmicae *et al.*, (2011) represented 0.002 mg/Kg.

The permissible amount of chromium for animal feed is 100-500mg/Kg recommended by (NRC, 2005). According to National Research Council recommendations at present time chromium has no negative effects on animal feed.

Concentration of Manganese

The experimental analysis of manganese metal in water hyacinth is presented in Figure 5. It was observed that the levels of manganese mostly accumulated in the root parts of the plants (Figure 5). Manganese concentrations in the roots (maximum value) were nearly twice as high as those in the leaves and stems. It was also perceived that around the Sher Ethiopia Company sampling site, the concentration of manganese was much higher than in Haile resort and Meki River sampling sites. The concentration of manganese in the roots at sampling sites of Sher Ethiopia, Haile resort, and Meki River was 518.8 mg/Kg, 371.6 mg/Kg, and 354.6 mg/Kg, respectively. The content of manganese in stem range from 153 to 322 mg/Kg. Around the Sher Ethiopia sampling site, a higher amount of manganese concentration in the stem was observed. The concentrations of manganese in the leave part of the samples were 252.4 mg/Kg, 118.1 mg/Kg, and 201.4 mg/kg in Sher Ethiopia, Haile resort, and Meki River, respectively.

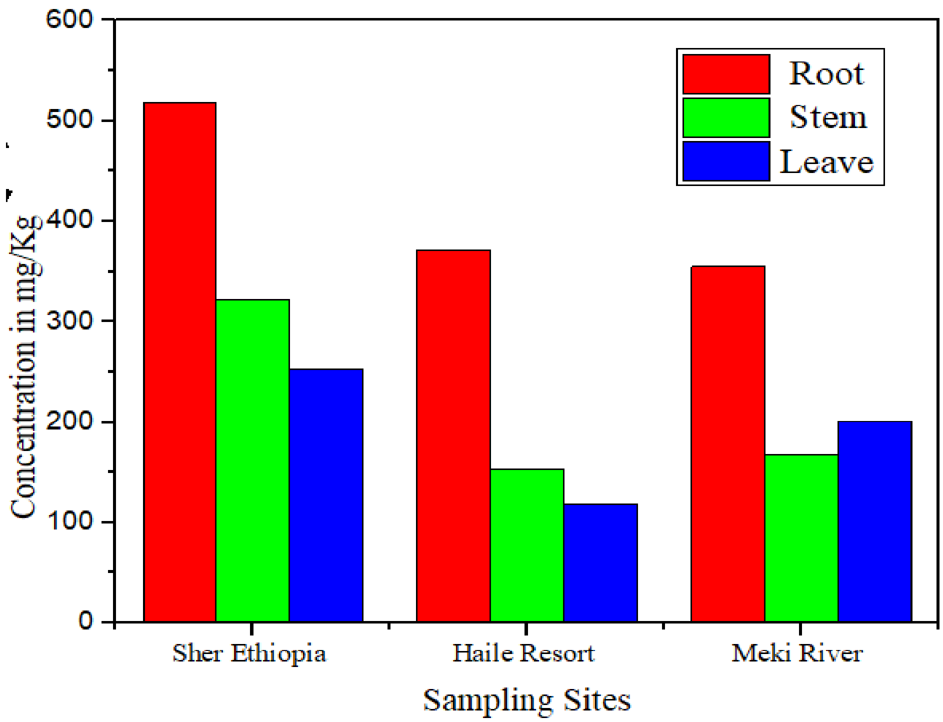

Figure 5: Variation of Manganese concentration in Different part of plant.

The concentration of manganese in this study was lower than reported by Matindi, (2016) who obtained the levels of manganese 484-3361mg/Kg, 595-2136mg/Kg, and 408-1835mg/Kg in the root, stem, and leaves, respectively. These results are higher than those obtained in this study.

Concentration of Copper

As shown in Table 4 copper concentration ranged from 22.89 to 57 mg/Kg in the root; 9.45 to 12.71 mg/Kg in the stem, and 6.78 to 11.33 mg/Kg in the leaves from the sampling site of Sher Ethiopia, Haile resort, and Meki River, respectively. From the sampling sites of the samples around Sher Ethiopia Company, the concentration of copper was higher than the rest of the two sampling sites. Its concentrations were 57 mg/Kg, 12.7 mg/Kg, and 11.33 mg/Kg in the root, stem, and leaves parts of the water hyacinth, respectively. In Meki River the concentration of copper in root 25.49 mg/Kg, stem9.45 mg/Kg, and 6.78 mg/Kg were recorded. In the Haile Resort site, the concentration of copper in the root is 22.89 mg/Kg, stem 12.54 mg/Kg, and leaves 7.84 mg/Kg.

Table 3: Concentration of Copper in water hyacinth in Lak Ziway mg.Kg^{-1} and maximum permissible limits of in animal feeds.

Sampling site	Plants part		
	Root	Stem	Leave
Sher Ethiopia	57±0.0577	12.7±0.0145	11.33±0.0133
Around Haile Resort	22.89±0.00882	12.54±0.00882	7.84 ±0.00577
Meki River	25.49±0.00577	9.45 ±0.01154	6.78 ±0.00577
MPL 250			

Source for MPL (NRC, 2005)

The concentration of copper in this study was higher than obtained by (Kumar & Srisai, 2019). However, lower than reported by (Khan *et al*. 2002). According to NRC (2005) coppers allowed maximum tolerable in animal feed is 15-250mg/Kg. At all the sampling sites and all parts of the water hyacinth, the concentration of copper was recorded below the permissible limit for animal feed.

Concentration of Iron

Table 5 shows the results of the iron concentration analysis of the samples investigated. In this study, iron was detected to be the highest occurring metal in the water hyacinth from different sampling sites of Lake Ziway. The concentrations of Fe ranged from 757.4 to 884.2mg/Kg, 47.8 to 74.05 mg/Kg, 37.97 to 130.7 mg/Kg, and the sample parts of root, stem and leaves, respectively. Iron was highly accumulated in the root of the plants in comparison to the other parts of the water hyacinth plant. In Sher Ethiopia Company iron levels in the water hyacinth part are as follows; 884.2 mg/Kg, 74.05 mg/Kg, 130.7 mg/Kg in the root, stem, and leaves, respectively.

Table 4: Concentration of iron in water hyacinth in Lak Ziway mg.Kg^{-1} and maximum permissible limits of some heavy metal in animal feeds.

Sampling site	Plants part		
	Root	Stem	Leave
Sher Ethiopia	884.2 ±0.0033	74.05±0.0185	130.7±0.000
Around Haile Resort	783.8±0.00882	34.28±0.0222	37.94±0.3328
Meki River	757.4±0.0145	47.8±0.0321	104.6±0.03512
MPL 1000			

Source for MPL (NRC)

Around the Haile resort sampling site, the concentrations of iron were 783.8 mg/Kg in the root, 34.28 mg/Kg in the stem, and 37.97 mg/Kg in the leaves. At the Meki River sampling site, the concentration of iron was 757.4 mg/Kg, 47.8 mg/Kg, 104 mg/Kg in root, stem and leaves parts of the samples. These high levels of Fe in all the sampling sites could be an indication of its great abundance in Lake Ziway. Ratan & Verma (2014) showed that iron was also discovered to be the most abundant and easily accumulated heavy metal by water hyacinth in a river contaminated by industrial and municipal waste. When compared to the results, the plant's average iron concentrations were determined to be 311.17, 4.89, and 2.94 mg/Kg in root, stem, and leave respectively. Despite the fact that their values are far higher than those found in this study, the trend is similar to the observation at the current study the order of the accumulation for iron was root>stem>leaves. The values of Fe obtained in this study were lower than the NRC (2005) recommended animal feed maximum limit, which is 1000 mg/Kg.

Concentration of Nickel

The concentration of nickel in different parts of the plant is shown in Figure 7. The concentration of nickel in the water hyacinth collected from Sher Ethiopia Company were 37.02 mg/Kg in the root, 4.98 mg/Kg in the stem, and 4.99 mg/Kg in the leave parts of the plant. the concentration of nickel in the sample collected from Around Haile resort were 17.74 mg/Kg in the root, 2.99 mg/Kg in the stem and, 3.99 mg/Kg in the leave part. similarly, the concentration of nickel in the root, stem, and leave part of the water hyacinth collected from Meki River sampling site were 23.4, 2.84, 3.64mg/Kg, respectively. The highest concentration of nickel in the plant samples was form both Sher Ethiopia and Meki River sampling sites.

Table 5: Concentration of Nickel in water hyacinth in Lak Ziway mg.Kg^{-1} and maximum permissible limits of some heavy metal in animal feeds.

Sampling site	Plants part		
	Root	Stem	Leave
Sher Ethiopia	37.02±0.0278	4.98±0.011	4.99±0.0882
Around Haile Resort	17.74±0.00882	2.99±0.0204	3.99±0.0251
Meki River	23.4±0.00577	2.84±0.099	3.64 ±0.00968
MPL 50-250			

Source for MPL (NRC, 2005)

In this study, the content of nickel in the water hyacinth from Lake Ziway was higher compared to that obtained by Adigwe, (2019). The maximum tolerable limit for nickel in animal feed recommended by the NRC (2005) is 50-250mg/Kg. In this study, the concentration of nickel in all sampling sites and all parts of the water hyacinth were below the permissible limit that was set by the NRC (2005).

Concentration of Lead

The concentration of lead in water hyacinth plant parts and different sampling sites from Lake Ziway is presented in Table 7. The analysis results showed that lead concentrations were not reported at the Sher Haile resort sampling site since they were below detection limits in all parts of the water hyacinth plants. Around Sher Ethiopia Company, and Meki River sampling sites, the concentration of lead in the root part of the sample was recorded. These study results showed no significant lead accumulation in water hyacinth plants collected from Ziway Lake and Meki River except for the root part of the plant. In the recent decades the concentration of lead in the vegetation have increased due to pollution by human activities. In uncontaminated locations, the lead concentration of edible portion of plants ranges from 0.05 to 3µg/g (Srinivas *et al.,* 2009). It clearly shows that the air or soil of the expanding lands is lead free, which contributes to the water hyacinth's safety from lead contamination. The permissible limit of lead in vegetables for animal feed is 10-100 mg/Kg (NRC, 2005).

Table 6. The concentration of Lead in water hyacinth samples mg.Kg^{-1} and maximum permissible limits of some heavy metal in animal feeds.

Sampling site	Plants part		
	Root	Stem	Leave
Sher Ethiopia	0.98	ND	ND
Around Haile Resort	ND	ND	ND
Meki River	0.7	ND	ND
MPL 10-100			

Note: ND not detected
Source MPL (NRC, 2005)

Concentration of Zinc

The analysis showed the presence of zinc in all the three samples collected from different sites at varying concentrations ranging from 63.75 to 89.9 mg/Kg in the root; 40.4 to 41.3 mg/Kg in the stem, and 25.67 to 39.9 mg/Kg in leaves (Table 8).

Table 7: Concentration of Zinc in water hyacinth in Lak Ziway mg.Kg^{-1} and maximum permissible limit of in animal feeds.

Sampling site	Plants part		
	Root	Stem	Leave
Sher Ethiopia	89.9±0.0173	39.24±0.002027	39.9±0.0120
Around Haile Resort	63.75±0.0173	41.03±0.02985	27.82±0.00318
Meki River	86.65±0.0176	40.4±0.0145	
MPL 300-500			25.67±0.0145

Source for MPL (NRC, 2005)

In this study, the concentration of zinc for all plant parts was recorded below the permissible limit set by the NRC for animal feed, that is, 300-500mg/Kg. From the water hyacinth, the root showed higher levels of zinc concentration in all sampling sites of the plant. However, levels of zinc in all parts of the sample were lower than obtained by (Matindi, 2016).

The Concentration of Pesticides in the Tissue of Water hyacinth

Organochlorine Pesticides

The level of organochlorine pesticides in the leave and roots of water hyacinth found in the study are shown in Table 11. the concentration of all organochlorine pesticides such as (α- BHC, β-BHC, Lindane, δ- BHC, Heptachlorepoxide isomer B, EndosulfanI, 4.4-DDE, Dieldrin, Endrin, Endosulfan II, 4.4-DDD, Endrin ketone, Bendiocarb, Bromophos-Ethyl, Chlorpyrifos , Methyl, Cyfluthrin 1, Cypermethrin 1(Zeta), Deltamethrin, Diazinon, Endrin aldehyde, 4.4-DDT analyzed were below the detection limits of the instrument which is 0.001.

Table 8: The concentration of Organochlorine Pesticides in Stem and Leave Water hyacinth.

Name of pesticides	Concentration (mg/Kg) Ziway sampling site		Concentration (mg/kg) Meki River site		MRLs (mg/Kg
	Stem	Leave	Stem	Leave	EU
α- BHC	<0.001	<0.001	<0.001	<0.001	0.1
β- BHC	<0.001	<0.001	<0.001	<0.001	0.01
Lindane	<0.001	<0.001	<0.001	<0.001	0.1
δ- BHC	<0.001	<0.001	<0.001	<0.001	0.01
Heptachlorepoxide isomer B	<0.001	<0.001	<0.001	<0.001	0.01
Endosulfan I	<0.001	<0.001	<0.001	<0.001	0.1
4,4-DDE	<0.001	<0.001	<0.001	<0.001	0.01
Dieldrin	<0.001	<0.001	<0.001	<0.001	0.2
Endrin	<0.001	<0.001	<0.001	<0.001	0.01
Endosulfan II	<0.001	<0.001	<0.001	<0.001	0.02
4,4-DDD	<0.001	<0.001	<0.001	<0.001	0.05
Endrin ketone	<0.001	<0.001	<0.001	<0.001	0.01
Bendiocarb	<0.001	<0.001	<0.001	<0.001	0.01
Bromophos-Ethyl	<0.001	<0.001	<0.001	<0.001	0.02
Chloropyrifos –Methyl	<0.001	<0.001	<0.001	<0.001	0.02
Cyfluthrin 1	<0.001	<0.001	<0.001	<0.001	0.01
Cypermethrin 1(Zeta)	<0.001	<0.001	<0.001	<0.001	0.1
Deltamethrin	<0.001	<0.001	<0.001	<0.001	0.2
Diazinon	<0.001	<0.001	<0.001	<0.001	0.02
Endrin aldehyde	<0.001	<0.001	<0.001	<0.001	0.1
DDT	<0.001	<0.001	<0.001	<0.001	0.05

Source for MPL (EU, 2002)

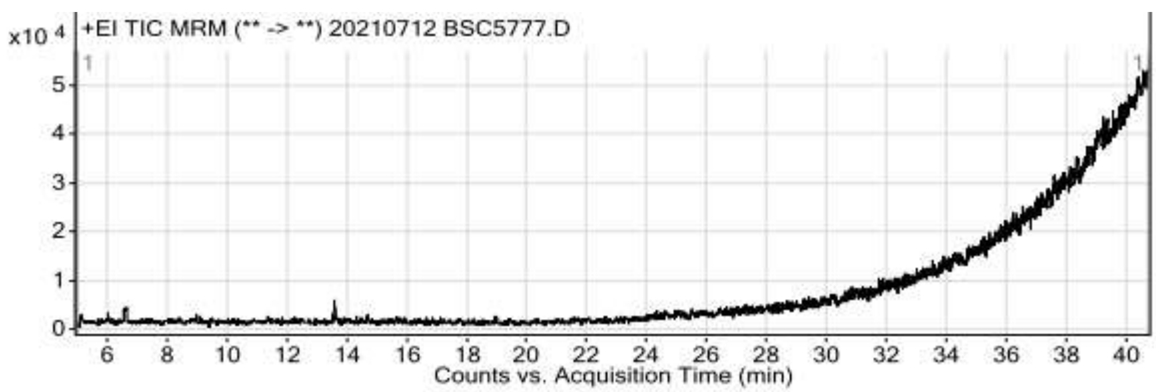

Figure 10: Chromatogram of organochlorine pesticides residue in Meki River stem part plant.

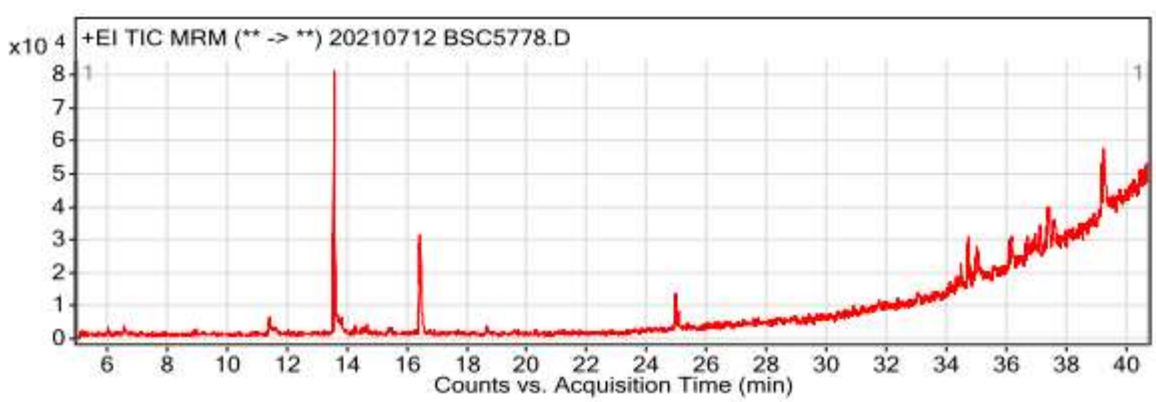

Figure 11: Chromatogram of organochlorine pesticides residue Meki River site in leave.

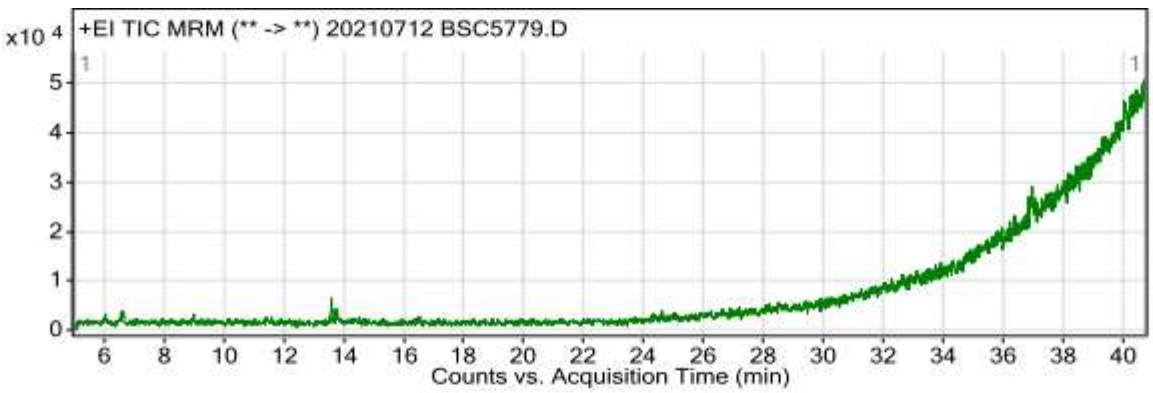

Figure 12: Chromatogram of Organochlorine pesticides residue Ziway site in stem part.

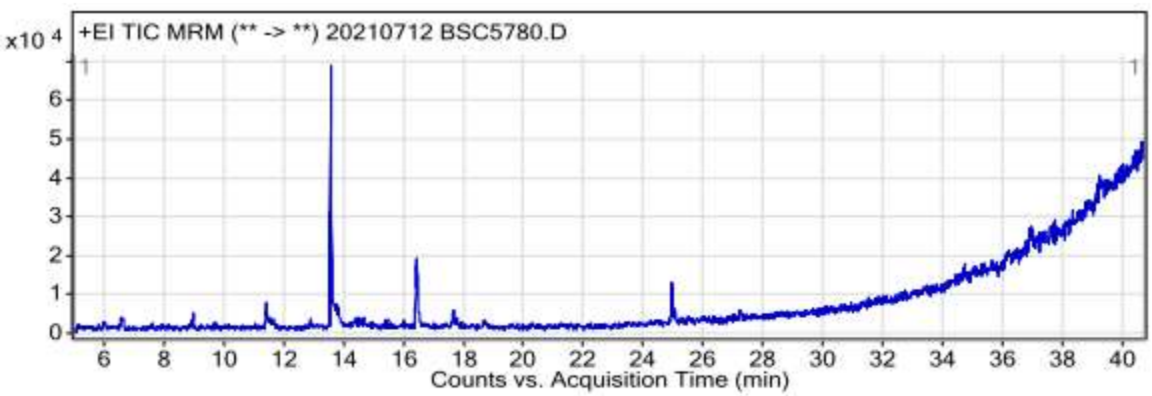

Figure 13: Chromatogram of Organochlorine pesticide residue Ziway site in leave part.

Organophosphate Pesticides Concentration

Table 11 shows the concentration of organophosphate pesticides residue in the water hyacinth in the stem and leave parts of sample. The results shows that none of the parts of the samples registered above detection limit. This is most likely due to their short half-lives, which means they don't stay active in the environment for very long (Lalah and Wandiga, 1996). The absence of organophosphate residues in samples does not always imply that organophosphate compounds have no environmental influence. They may have a short-term impact on the aquatic system before decomposing into non-toxic compounds and also below the detection limit of the organophosphate pesticides in the water hyacinth samples in the study area was probably because no current use of these pesticides by the farmer for different purpose around the Lake Ziway. Small-scale vegetable growers around the littoral zone of Lake Ziway in Ethiopia do not use the most harmful pesticides which is listed of class 1a and 1b by WHO, as well as banned pesticides such as the notorious DDT, dieldrin, HCB, HCH, chlordane, and Endosulfan(Mergia*et al.*, 2021). Organophosphate pesticides also known as non- persistent compounds of low water solubility (Aislabie *et al.*, 1997), and there for, below the detection limit of these types of pesticides residues was as expected. This could be due to the fact that, depending on the formulation, the rate and manner of application, and environmental circumstances, they degrade quickly. Furthermore, the degradation is aided by high solubility and a relatively short life in the environment (Abd El-Gawad*et al.*, 2014). (Berhan *et al.*, 2016) studded the impacts of nutrient and pesticide from the small and large scale agriculture on the water quality of Lake Ziway, Ethiopia from 2009-2015. The results indicate that the pesticide trends are decreasing especially the year of 2014 and 2015. The concentration of organophosphate pesticide residues obtained in this study from the Lake Ziway in two different sampling points were generally not line with the previous study obtained by Deribe *et al.,* (2014). How every except DDT other pesticides residue in this study was similar obtained by (Mergia *et al.,* 2021).

Table 9: The concentration of organophosphate pesticides in Stem and Leaves Water hyacinth.

Name of pesticides	Concentration mg Kg^{-1} Ziway sampling site		Concentration mg Kg^{-1} Meki sampling site		MRLs (mg/Kg)
	Stem	Leave	Stem	Leave	EU
Dichlorobenzonitrile	<0.001	<0.001	<0.001	<0.001	0.1
Ethion	<0.001	<0.001	<0.001	<0.001	0.05
Famphur	<0.001	<0.001	<0.001	<0.001	0.01
Fenitrothion	<0.001	<0.001	<0.001	<0.001	0.01
Fenthion	<0.001	<0.001	<0.001	<0.001	0.01
Hexachlorobenzene	<0.001	<0.001	<0.001	<0.001	0.01
Indoxacarb	<0.001	<0.001	<0.001	<0.001	0.01
Malathion	<0.001	<0.001	<0.001	<0.001	0.01
Parathion	<0.001	<0.001	<0.001	<0.001	0.01
PipronylButoxide	<0.001	<0.001	<0.001	<0.001	0.01
Profenophos	<0.001	<0.001	<0.001	<0.001	0.01
Propargite	<0.001	<0.001	<0.001	<0.001	0.01
Propoxur	<0.001	<0.001	<0.001	<0.001	0.01
Thionazin	<0.001	<0.001	<0.001	<0.001	0.01

Source for MPL (EU, 2002)

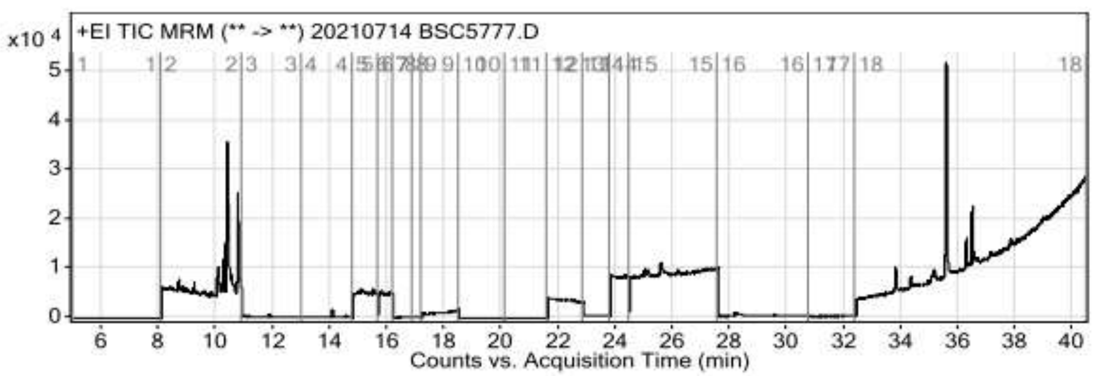

Figure14: Chromatogram of Organophosphate pesticide residue in Ziway site in stem part.

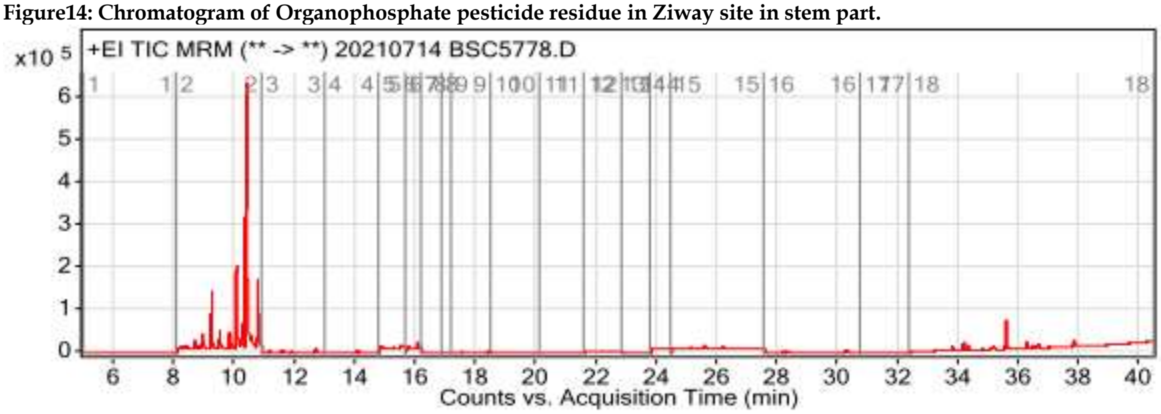

Figure 15: Chromatogram of Organophosphate pesticide residue Ziwaysite in leave part.

Figure 16: Chromatogram of Organophosphate pesticide residue Meki site in stem part

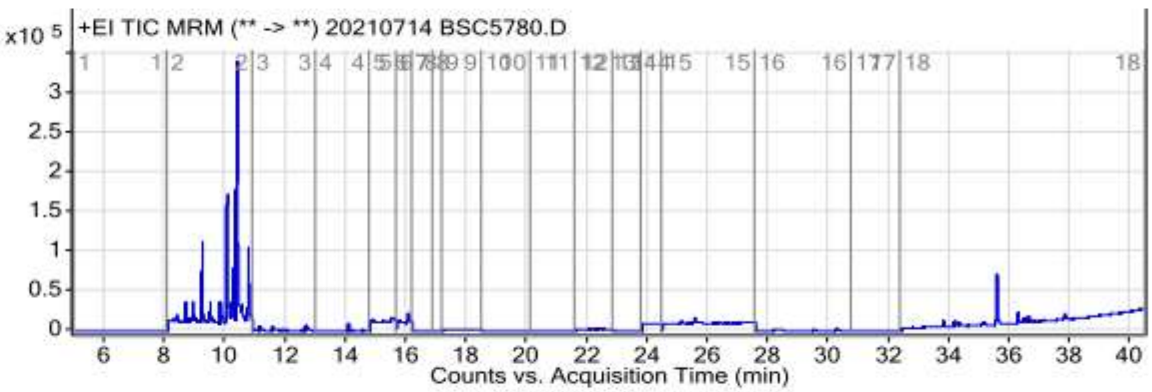

Figure 17: Chromatogram of Organophosphate pesticides residue Meki site in leave part.

Nutritional/ Animal feed/ Characteristics of Water hyacinth

The mean moisture content in the stem and leaves of water hyacinth shown in Table 12. The moisture content in the stem was the lowest (3.96%) compared with the moisture content in the leave (9.34%). The moisture content of feed is a measure of its water activity (Frazier and West off, 1978) and is used to estimate its stability and its vulnerability to microbial contamination (Scott, 1957). The moisture content in both the stem and leaves of the water hyacinth is lower the value reported by (Akmal *et al*., 2014).

Table 10: Determination of proximate composition of water hyacinth.

Parameter	Plant parts Stem	Leaves	Animal feed recommended concentration
Moisture (%)	3.96±0.01000	9.34±0.03500	—
Crude protein (%)	2.17±0.0100	18.03±0.44500	17%
Crude fat (%)	0.47±0.0200	1.42±0.01000	4%
Crude ash (%)	5.23±0.0100	17.04±0.02000	—
Crude fiber (%)	6.70±0.0100	31.87±0.03000	2.5%
Carbohydrate (%)	81.47±0.1600	22.30±0.095000	—
Energy (Kcal)	338.79±0.0400	174.10±0.05000	—

Sources for animal feed recommendation concentration: (Vest & Dale, 2015)
Note: Dash indicated that information is not available

The percentage of crude protein varied from 2.17% in the stem to 18.03% in the leave, with a mean of 10.1% for both stem and leave samples. However, Akmal *et al.* (2014) reported lower crude protein concentration in the leaves while the value reported from the stem was higher (9.96%) than in the present study. In this study, leaves water hyacinth had a higher crude protein content than corn grit maize (10.77%) Boyd (1974); and guinea corn (11.22%) Eyo, (1994). These are components that are either directly consumed by chicken or utilized as a primary component in the formulation of chicken feed.

The content of crude fat was found to be 0.47% in the stem to 1.42% in the leaves, with the mean of 0.945%. The crude fat found in this study was lower than the value reported by reported by Okoye *et al.*, (2000) which was 1.56% in the leave and 2.10% in the stem. However, Akmal*et al.*, (2014) lower crude fat content in both stem (0.19%) and leave (0.21%) than the present study. Plants with higher amounts of crude fiber are important for the treatment of obesity, diabetes, cancer and gastrointestinal disorders, prevent coronary heart disease, hypertension, and constipation Ibironke, (2013; Iniaghe, (2009). Water hyacinth leaves are high in crude fiber, which is a dietary benefit since crude fiber aids digestion and reduces cholesterol absorption.

The results showed that water hyacinth *(Eicchoriacrassipies*) crude ash content was 5.23% in stem and 17.04% in leaves. The values are higher than those of AlchorneaCorditolia (Euphorbiaceae) which was 3.65% in leave and 10.37% in stem (Ngaha*et al.*, 2016) whereas,Okoye *et al.* (2021) reported lower ash content in both leave (16.79%) and stem (18.48%)of water hyacinth.

The results indicate that water hyacinth (*Eicchoriacrassipies*) accumulate low crude fiber (6.7%) in stem and high (31.87%) in the leave part of the water hyacinth in contrast with 20.80% in stem and 13.73% in leave obtained from water hyacinth (*Eicchoriacrassipies)* Akmal*et al.*,(2014). When compared with the value of fiber obtained from the other work, the leave part had more than the stem, 15.23% and 20.80% respectively, reported by Okoye *et al.*, (2021).

Carbohydrate plays a major essential role in the body as a source of energy as well as structural materials Voet*et al.*, (2008). The results show that water hyacinth (*Eicchoriacrassipies)* has a carbohydrate content of 81.47% in stem and 22.30% in leaves. These results are higher in stem 81.47% and lower in leaves 22.36% obtained by Akmal*et al.*, (2014) but in the leave part of the sample, low carbohydrate content, that of *Leptadeniahastata* leaves (45.45%) as reported by Yirankinyuki *et al.*, (2015). Carbohydrate content is the most abundant in the leaves, this shows that the leaves of the water hyacinth can serves as good sources of energy for the body.

The energy value of water hyacinth (*Eicchorniacrassipies*) was found to be 338.79KJ/100 g in stem and 174.10KJ/100 g in leaves. On the other hand, Suleiman *et al.* (2019) obtained lower energy value of the water hyacinth in the leave parts (252.52KJ/100g) while, it was higher in the stem.

This study indicates that the water hyacinth plant, especially the leaves part, has good nutritional content. According to Vest and Dale (2015), the various types of nutritional requirement of poultry are 18-22%, 17-20%, 16-18% for protein; 4% crude fat, and 2.5-4% for crude fiber for broiler, pullet and laying respectively. In this study, the proximate analysis shows that the leaves part of the water hyacinth sample were good protein sources.

CONCLUSION AND RECOMMENDATIONS

Conclusion

In this study, heavy metal, pesticide residue, and nutritional value of different parts of water hyacinth from Ziway Lake has been investigated. The total heavy metal concentration varies between ND to 884.2 mg/Kg dry weight. All heavy metals such as cadmium, copper, iron, lead, zinc, nickel, manganese, chromium in different part of the water hyacinth was below the NRC (2005) maximum tolerable level for animal feed. The finding of this study confirmed that the study area were heavy metals in water hyacinth are safe for animal feed because the heavy metals concentration was below permissible level in plant recommended by NRC (2005) for animal feed. Both organochlorine and organophosphate pesticides residue concentration are <0.001mg/Kg dry weight. Compared with the EU regulation for pesticide residue in plant for animal feed, this investigation pesticide levels do not above the existing limits. According to the nutritive value analysis water hyacinth is rich in nutrition particularly the crude protein, high energy, and carbohydrate. Most aquatic plants have good potential as animal feed. Among thiswater hyacinth is one of the aquatic plants. Based on this investigation, water hyacinth appears to be particularly nutritive, as the protein level is higher than other feed ingredients utilized in animal feed formulation. The overall data from this study confirmed that the water hyacinth plants especially leaves are suitable and safe for consumption by animals in the study area.

Recommendations

The following recommendations are made with the reference to the result and overall findings obtained from the research in order to help improve the utilization of water hyacinth within the Lake Ziway. Essential elements like phosphorous, calcium, potassium, and pH, and some toxic elements should be tested from the water hyacinth which, are not addressed in this study like arsenic, mercury etc.

In terms of nutritional content water hyacinth can be used as a supplement for animal feed, but other compounds may be toxic for animal which need a research. Based on its content of heavy metals, pesticides and nutritional content the water hyacinth from Lake Ziway can be used as animal feed. However, further study is requiredfor specific animals such as sheep, goat, poultry, beef and dairy.

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