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Effect of different concentrations of Acetic acid on water hyacinth [*Eichhornia crassipes* (Mart.) Solms], aquatic life and physicochemical properties of water under pond conditions

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ABSTRACT

The experiment was conducted in concrete ponds under a screen house built on the lakeshore of Lake Tana to study the effect of different concentrations of acetic acid on water hyacinth, aquatic life and the water quality. In each pond 16 young water hyacinth plants and 12 Nile tilapia individuals were introduced. The ponds were 6 m^3 in volume and filled with water pumped from Lake Tana to simulate the natural environment. The treatments were prepared as 0% (control), 5%, 10%, 15% and 20%, each treatment was replicated three times in the same pond. Increasing acetic acid concentrations progressively suppressed water hyacinth growth and development whereas it didn't affect the survival of the Nile tilapia but reduced water quality. Spraying 20% concentration of acetic acid lead to entire damage of water hyacinth within short time, whereas the application of 15% and 10% concentration of acetic acid permitted the production of new daughter plants for another infestation and needed subsequent spraying, while 5% was less effective. Therefore, using a 20% concentration of acetic acid was recommended for controlling water hyacinth.

Keywords: Acetic acid, Daughter plants, Nile tilapia.

INTRODUCTION

Water hyacinth [*Eichhornia crassipes* (Mart.) Solms] is one of the most terrible aquatic weed in the globe. The Amazon Basin in South America is considered as the origin; however it has currently dominated many countries (Julien, 2001). Its predictable spread was due to its free-floating habit and showy flowers made it attractive for use in ornamental ponds and garden pools. In Ethiopia, it was introduced purposely as an ornamental plant (Tegene and Ayele, 2014). Afterwards, accidentally, as Mengist and Moges, (2019) reported, water hyacinth has been found in rivers, power dams, reservoirs, lakes, irrigation, and drainage canals. They also indicated that the occurrence of the weed in water bodies was officially reported for the first time in 1965 at Koka Lake and in the Awash River. Abasamuel Dam which is organically enriched by Akaki River is assumed to be the the point of introduction and primary source of infestation to the Awash River (Tegene and Ayele, 2014). Later, it has been introduced to different parts of the country and has infested several waterways, lakes, rivers, and power dams (Admas *et al.*, 2017).

Lake Tana is located in the north-western part of Ethiopia it is the largest freshwater body in the country (Wassie *et al.,* 2014). It is a versatile water body where many people depend on it for Agriculture, fishing, transportation, hydroelectric power generation, and recreation (Wassie *et al.*, 2014). due to its islands that shelter attractive churches and monasteries, has made Bahir Dar city, tourist destinations in Ethiopia (Wassie *et al.,* 2014). However; currently this multi-purpose lake is challenged by water hyacinth infestation. The infestation of the weed was first reported in 2011(Dereje, 2015). A year after this report, about 20, 000 ha shore area of the lake was infested by water hyacinth. In 2014 water hyacinth coverage was doubled and reached about 40, 000 ha (Wassie *et al.*, 2014). Nowadays, a large area of the Lake Tana is covered by this invasive alien weed. Following this infestation the Amhara National Regional State (ANRS) Bureau of Environmental Protection, Land Administration, and Use (BoEPLAU) launched a physical removal campaign to control the weed and this has been continuing to date with less impact. Management of this invasive alien weed on water

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bodies via physical and mechanical control methods appears less successful and calls for more integrated control strategies.

Acetic acid or Ethanoic acid (Chemical formula $C_2H_4O_2$; Structure CH3COOH) is a colorless, liquid, organic compound generally classified as a weak acid. It is one of the oldest chemicals known to humanity and is produced naturally during spoilage of fruit and certain other foods through the activity of acetic acid bacteria like *Acetobacterium*, which is commonly found in foodstuffs, water, and soil (Theron and Lues. 2011).

Acetic acids exist commercially in concentrations ranging 6% to 99.4%. Glacial acetic acid is a water-free (anhydrous) acetic acid and has concentration of 99.4%. The hazards of solutions of acetic acid depend on the concentration; solutions with concentration of more than 11% acid are corrosive to skin and thus must be handled carefully with personal protective equipment (PPE) (U.S. Department of Labor, 1992; Fiola and Gill, 2017, Webber et al, 2018).

Diluted or an aqueous solution of acetic acid is called Vinegar. As vinegar, it has been produced as long as wine making has been practiced and therefore dates back to at least 10,000 B.C. It is assumed that the first vinegar was a result of spoiled wine and therefore given its name acetic acid derived from the Latin word *acetum* means sour or sharp wine.

Use of Acetic acid as an eco-friendly herbicide is a recent development. Acetic acid as when applied as herbicide affects the cell membranes of a plant, causing rapid breakdown/desiccation of foliage tissue on contact (Fiola and Gill, 2017). Acetic acid does not persist in the environment; rather, it readily breaks down producing water, carbon dioxide and carbon mono oxide as a by-product (U.S. Department of Labor, 1992; Webber et al, 2018)

Using bio-control methods and eco-friendly herbicides such as acetic acid were found effective in many countries in terms of its cost and feasibility for aquatic weed management rather than using mechanical and physical control methods (El-Shahawy, 2015). Terrestrial and aquatic weeds can be controlled safely, effectively and cheaply by the use of acetic acid, (El-Shahawy, 2015). It affects the stem, the stolen, and leaf part of the water hyacinth sufficiently within a short period as compared to other chemicals, meanwhile its effectiveness increases as its concentration increases (Agidie *et al.*, 2018). Hence, this research work was conducted to evaluate the effects of different concentrations of acetic acid on the growth and development of water hyacinth plants, other aquatic life and water quality.

MATERIALS AND METHODS

The experiment was conducted under 10 m x 35 m screen house built on the lakeshore of Tana which sheltered four $6m^3$ (6m x 1m x 1m) concrete ponds filled with water pumped from Lake Tana to simulate the natural environment. Floating plots (50cm*30cm) were prepared in each concrete pond using plastic tubes. Water hyacinth plants were collected from the highly invaded water body of Lake Tana by removing the dead parts. Following careful washing of the plants with tap water, 16 daughter plants were separated from their mother and introduced to every pond with their respective floating plots. One dougher plant per plot was used to detect the emergence of other new doughter plants after a while, as a length of the concrete pond is 6 meters, hence, a set of floting plots containing 16 plants were replicated three times within one pond, 0.7meter spacing between replications.

Nile tilapia (*O.niloticus*) fish species were obtained from Bahir Dar Fishery and Other Aquatic Life Research Center (BFALRC). Twelve of this species were released in each pond before applying treatments to observe the effects of different acetic acid concentrations on fishes. The fishes were acclimatized for two days in each concrete pond before spraying acetic acid to reduce the effects of Nile tilapia death due to stress and any other confounding factors during transportation from BFALRC.

The treatments were 0% (control, a spray of only distled water), 5%, 10%, 15%, and 20% acetic acid concentration sprayed on water hyacinth plants. Every pond received a single treatment, due to only four concreat ponds built; the 0% treatment data collection was taken first, before conducting other four treatments. Visual follow-up was started three hours later and continues for thirty days after treatments were applied to notice fish mortality and symptoms of phytotoxicity on water hyacinth, whereas water samples were taken before and after treatment application for plankton and water quality analysis.

Spray volume preparation

The original acetic acid (99.4%) and distilled water were used to prepare a solution for each treatment. The concentration were determined by using the formula $C_1V_1=C_2V_2$ Where C1V1 were the original concentration and C2V2 were the final concentration and volume of the dilution. Therefore, 10.1 ml of acetic acid and 189.9 ml distilled water was used to prepare 5 % acetic acid concentration solution whereas 20.2 ml acetic acid and 179.8 ml distilled water was used to prepare a 10% acetic acid concentration solution. Likewise, 30.3 ml acetic acid and 169.7 ml distilled water was used to prepare a 15 % acetic acid concentration solution but 40.4 ml acetic acid and 159.6 ml distilled water was required to prepare 20% acetic acid concentration solution. The spray was conducted using hand held sprayer with half litter capacity, until fully wet of the leaves, the spray was amended with 0.1% (v/v) Tween-80 as an adjuvant.

Water physicochemical parameters analysis:

Measurements of dissolved oxygen (mg/L), pH, specific conductivity (µs/cm^2), total dissolved solids (mg/L), salinity (ppt), temperature (^{O}C), alkalinity (mg/L $CaCO_3$), sulfate (mg/L), H_2S(mg/L) and total hardness (mg/L $CaCO_3$) were carried out using a portable water analysis kit (YSI 556 multi-probe system) to analyze the effects of acetic acid on water quality.

Plankton analysis:

Water samples were collected from each treatment using a bucket. Afterward, zooplankton and phytoplankton samples were collected by 80µm and 50µm mesh net filtering devices. Zooplankton was preserved in formalin and phytoplankton in Lugol's iodine solution. Identification and enumeration of planktons were made using a standard operating procedure for phytoplankton analysis (US Environmental Protection Agency, 2003).

Fish survival assessment:

Follow-ups continue throughout the experimentation to observe if any fish floated dead, whereas at the end of the experiment the water was drained and fishes counted.

Image analysis:

One month after treatment application, images were taken at equal distance from all concrete ponds for image analysis using CIMMYT maize scanner software to observe the amount of green area left for regeneration after treatment application.

Data on the number of water hyacinth plants damaged, the severity of the damage, the number of daughter plants produced, the number of stolen produced, and Nile tilapia fish mortality were recorded. The severity of damage was expressed as the percentage or proportion of the water hyacinth leaf area destroyed by the spray. Data on physicochemical properties of water, zooplankton, and phytoplankton abundance were also recorded at the end of the month. Data were subjected to analysis of variance (ANOVA) using SAS software Version 9.1. Least Significant Difference (LSD) values were used to separate differences among treatment means.

RESULTS

Effects of acetic acid on water hyacinth:

The controlling efficacy of acetic acid on water hyacinth increased with an increase in concentration from 5 to 20%. The highest concentration (20%) was found to be the most effective in terms of the number of water hyacinth plants damaged, the severity of the damage, and the daughter plants produced (Table 1). Spraying a 20% concentration of acetic acid damaged water hyacinth plant tissue 100% and sank gradually accompanied by algal growth covering the water surface. This algae bloom seemed to be the result of nutrient release from decaying plants and also of a greater supply of light for photosynthesis due to the disappearance of the water hyacinth plant cover. Whereas spraying 5%, 10%, and 15% concentration of acetic acid damaged water hyacinth plant stem, stolen and leaf parts by 44.33%, 64.33%, and 80% respectively (Table 1).

Table 1: Effects of different concentration of acetic acid on water hyacinth growth

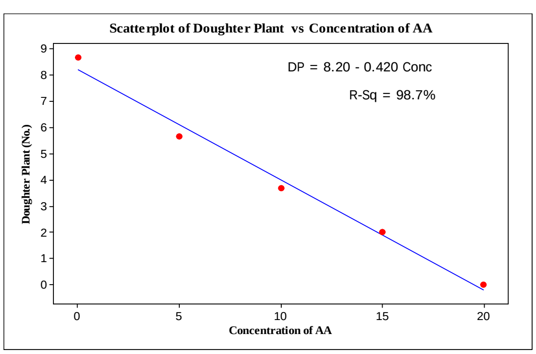
AAC (%)	NDP	SD	DPP	GA	NSP
0	0.00[e]	0.00[e]	8.67[a]	0.88[a]	6.00[a]
5	11.40[d]	44.33[d]	5.67[b]	0.41[b]	5.00[a]
10	13.70[c]	64.33[c]	3.67[c]	0.279[c]	2.00[b]
15	14.27[b]	80.00[b]	2.00[d]	0.11[d]	1.00[bc]
20	16.00[a]	100.00[a]	0.00[e]	0.04[e]	0.00[c]
GM	11.07	57.73	4.20	0.34	2.80
CV	1.36	6.03	15.05	2.44	33.70
Sig (0.05)	**	**	**	**	**

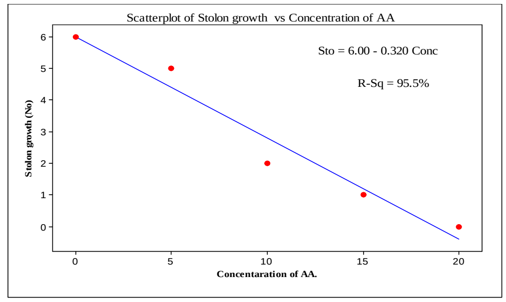
Where: AAC (%) =Acetic acid concentrations; NDP=Number of damaged plants; SD= Damage (%) /severity of damage; DPP= Daughter plants produced; GA= Green area; NSP=No of stolons produced; CV = coefficient of variation; Sig (0.05) = Significance level at 5%; GM=grand mean

The 20% concentration showed rapid phytotoxicity symptoms on water hyacinth leaves indicating the mode of action of acetic acid is contact. The leaves of the weed turned to dark green and then brown color, followed by death as an eventual result because of dehydration (Fig. 1). These all images showed different effects of acetic acids on water hyacinth with respect to their concentrations (figure 1). The rate of production of water hyacinth daughter plants decreases as the concentration of acetic acid increased from 5% to 20%. When the concentration of acetic acid increased by 1% the number of daughter plants produced decreased by 0.42 when other factors are constant (Fig. 2).

Effects of different concentration of acetic acid on the number of water hyacinth stolen production:

The same trend was obtained as of the daughter plant production, water hyacinth stolons production decreases as the concentration of acetic acid increases from 5% to 20%. When the concentration of acetic acid increased by 1% the number of water hyacinth stolons produced decreased by 0.32 when other factors are constant (Fig. 3). The image analysis depicted that there was a decrease in green leaf area left with an increase in acetic acid concentration whereas the untreated pond had the largest photosynthetic (green) area and there was a statistically significant difference (p<0.05) among





Where: AA=acetic acid; Con= concentration; Sto= stolon; R-Sq. = R-squared

Fig. 1: Scatter plot of the number of stolons produced vs acetic acid concentration

treatments (Table 1).

Effects of different concentration of acetic acid on physicochemical properties of water:

Water temperature:

Water sample analyses depicted that there was a significant difference ($p < 0.05$) in water temperature between acetic acid sprayed treatments and the control (Table 2). This increase in water temperature in control treatment could be associated with the dense mats of water hyacinth over the water surface, which blocks the exchange of heat between the water surface and the atmosphere.

Specific conductivity of water:

The analysis of variance indicated a highly significant difference ($p<0.05$) among acetic acid sprayed treatment means and the control treatment on water-specific conductivity (Table 2). An increase in specific conductivity of water with an increase in acetic acid concentration was due to an increase in the amount of water hyacinth decomposition and the release of CO_2 from acetic acid disintegration (table 2).

Total dissolved solids in water (TDS):

An increase in total dissolved solids of water with an increase in acetic acid concentration was due to the decomposition of water hyacinth plant parts in water (Table 2). On the other hand, a decrease in total dissolved solids of control treatment was due to the phytoremediation potential of the plant. However, changes in the amounts of dissolved solids in water can be harmful because the density of total dissolved solids determines the flow of water in and out of an organism's cell which may lead to the death of many aquatic organisms. However, spraying different concentrations of acetic acid on concrete ponds had a TDS range of drinking water 25-250 mg/L.

Dissolved oxygen (DO):

Dissolved oxygen level that is too high or too low can harm aquatic life and affect water quality. The range of dissolved oxygen level in all concrete ponds was 6.3-8.26 mg/L and it is within the range

Table 2 Effect of different concentration of acetic acid on physicochemical properties of water

AAC (%)	Temp(^{0}c)	SC	TDS	salinity	DO	pH	hardness	Alkalinity	SO_4^{2-}	H_2S
0	24.33^a	133^c	88^c	0.06	6.03	6.69	70.00^c	56.00^c	5.00^a (0.78)	0.08
5	18.35^b	151^b	107^b	0.09	7.14	6.97	80.00^{bc}	68.00^b	0.00^b (0.00)	0.08
10	18.56^b	169 ^{a}	125^a	0.09	8.26	7.26	90.00^{ab}	80.00^a	0.00^b (0.00)	0.07
15	18.63^b	174 ^{a}	129^a	0.09	8.14	7.38	90.00^{ab}	73.00^{ab}	0.00^b (0.00)	0.08
20	20.73^{ab}	172 ^{a}	121^a	0.09	7.94	7.56	102.00^a	80.00^a	0.00^b (0.00)	0.05
GM	20.12	159.8	114	0.08	7.50	7.17	86.40	71.40	1.00	0.07
CV	10.22	5.02	5.37	24.06	13.95	9.48	8.36	6.37	44.72	17.7
Sig (p=0.05)	*	**	**	NS	NS	NS	**	**	**	NS

Where: AAC (%) =Acetic acid concentrations (%); Temp= Temperature; SC = specific conductivity; TDS = total dissolved solids; DO= dissolved oxygen; pH= hydrogen ion concentration; SO_4^{2-} =Sulphate; GM=grand mean; H_2S= hydrogen sulfide; CV=coefficient of variation; Sig (0.05) =significance level at 5%.

Table 3: Effects of acetic acid on phytoplankton abundance (cell/ml)

AAC (%)	*Chlorella sp.*	*Cyclotella sp.*	*Phucus sp.*	*Perdinum sp.*	*Oocystis sp.*	*Microcystis sp.*
0	2000.0^a	80.0^a	18.0^a	6.0^a	50.0^a	4000.0^a (3.6)
5	1600.0^b	55.0^b	15.0^{ab}	5.0^{ab}	32.0^b	0.0^b (0.00)
10	1200.0^c	30.0^c	12.0^b	4.0^b	15.0^c	0.0^b (0.00)
15	750.0^d	30.0^c	6.0^c	2.0^c	7.0^d	0.0^b (0.00)
20	400.0^e	20.0^d	4.0^c	2.0^c	3.0e	0.0^b (0.00)
GM	1190.0	43.0	11.0	3.80	21.40	800.0
CV	15.54	7.78	17.72	23.54	8.36	27.95
Sig (p=0.05)	**	**	**	**	**	**

Where: GM=Grand mean; CV=Coefficient of Variation; Sig (0.05) =significance level at 5%; AAC (%) =Acetic acid concentration

Table 4: Effects acetic acid on zooplankton abundance (individual/L)

AAC	*Keratella*	Cyclo	Nou	*Brachionus*	Cerio	*Alonea sp.*	Polya
0	36.0^a (1.57)	18.0^a	28.0^a	24.0^a (1.40)	4.0^a (0.7)	14.0^a (1.18)	28.0^a (1.46)
5	34.0^a (1.54)	14.0^{ab}	26.0^a	12.0^b (1.11)	4.0^a (0.7)	11.0^b (1.08)	19.0^b (1.3)
10	27.0^b (1.45)	12.0^{bc}	24.0^a	10.0^b (1.04)	4.0^a (0.7)	8.0^c (0.95)	10.0^c (1.04)
15	0.0^c (0.00)	8.0^{dc}	10.0^b	5.0^c (0.78)	0.0^b(0.0)	0.0^d (0.0)	3.0^d (0.6)
20	0.0^c (0.00)	5.0^d	6.0^b	0.0^d (0.00)	0.0^b (0.0)	0.0^d (0.0)	0.0^e (0.0)
GM	19.40	11.40	18.8	10.20	2.40	6.60	12.0
CV	12.94	22.70	15.5	15.50	29.46	20.33	10.86
(p=0.05)	**	**	**	**	**	**	**

Where: AAC (%) =Acetic acid concentration; Cyclo =Cyclopoid species; nou= Nouplii; Cerio =Cerio- dapnia species; Polya =Polyarthra species; GM=Grand mean; sig (0.05) =significance level at 5%; CV =coefficient of variation

indicated by Chesapeake Bay Program 1983 which is appropriate for bottom feeders, crabs, oysters, and worms (1-6 mg/L), and shallow water fish (4-15 mg/L).

Water hardness:

The water hardness in the untreated pond was lower (70.0) than the pond which received the highest concentration (20%) of acetic acid (102.0) (Table 2). This is attributed to the existence of water hyacinth which has phytoremediation potential that removes multivalent metallic ions in the water. On the other hand, an increase in total hardness of water with an increase in the concentration of acetic acid from 5% to 20%, it was due to the decomposition of water hyacinth plant parts in water and releases dissolved nutrients and a variety of other metals in the water that increases water hardness level.

Sulfate:

The analysis of variance indicated a significant difference ($p<0.05$) among acetic acid sprayed treatments and the control treatment on water sulfate content (Table 2). This might be due to the reduction of sulfate by microorganisms and the utilization of sulfate as a source of sulfur for aerobic organisms.

Effects of different concentration of acetic acid on phytoplankton abundance:

The phytoplankton abundance was generally decreased with an increase in acetic acid concentration (Table 3). An increase in the concentration of acetic acid and subsequent decay of water hyacinth plant parts had showed a significant impact on phytoplankton abundance

Effects of different concentration of acetic acid on zooplankton abundance:

Zooplankton abundance was generally decreased with an increase in acetic acid concentration (Table 4). An increase in the concentration of acetic acid and subsequent decay of water hyacinth plant parts had a significant impact on Zooplankton abundance.

Survival of Nile tilapia (O. niloticus):

Survival test for Nile tilapia fish was conducted for one month after treatment application and found that all the fishes applied survived and showed visible body size increment during the inspection of their survival at the end of the experiment.

DISCUSSIONS

A long history of experimentation have had on terrestrial weeds using natural products having potential herbicidal activity, but no more efforts were done for their effects on aquatic weeds (Bhadoria 2011; Duke *et al*. 2002; Jabran *et al*. 2010; El-Shahawy and Abdelhamid 2013; Nekonam *et al*. 2014).

Many patents were approved by the US Patent Office with natural ingredients such as, propionic acid, acetic acid, formic acid, fatty acids and essential oils, that can be used successfully in controlling weeds (Chase *et al*. 2004; Wilson *et al*. 2007; Koivunen and Marrone 2013). The ingredients' containing organic acids act by manipulate the cell membrane of the plants, causing a quick collapse/dehydration of foliage tissue upon make contact with (Fiola D. S. and Gill S. (2017)). Terrestrial and aquatic weeds can be controlled safely, effectively and cheaply by the use of acetic acid, (El-Shahawy, 2015). It affects the stem, the stolen, and leaf part of the water hyacinth sufficiently within a short period as compared to other chemicals, meanwhile its effectiveness increases as its concentration increases (Aklilu Agidie *et al.*, 2018).

The suppressing efficacy 10 and 15% concentrations in our finding were relatively lower than what Aklilu Agdie *et al*., (2018) and El-Shahawy, (2015) reported. According to El-Shahawy, (2015) spraying 10 and 15% concentration of acetic acid suppress water hyacinth by 85 and 86% respectively; while Aklilu Agdie *et al*., (2018) reported that spraying 15%, 20% and 25% concentration of acetic acid suppress water hyacinth by 100%. This might be due to the use of old water hyacinth plants (Ashton ***etal.***, 1991). Treatment showed rapid phytotoxicity symptoms on water hyacinth within 3-5 hours which showed that the mode of action of acetic acid is contact (Aklilu Agdie et al., 2018). The effectiveness of chemicals increased as their concentration was increased from 15% to 25%. The highest concentration (25%) was most effective compared with the low (15%) and medium (20%) concentrations. Acetic acid controlled the growth of water hyacinth by 100% (Aklilu Agdie et.al 2018).

In his study about chemicals with a natural reference for controlling water hyacinth, El-Shahawy (2015) reported five compounds, namely: acetic acid, citric acid, formic acid, and propionic acid, in three concentrations (10, 15, and 20%) applied as a foliar application under wire-house conditions) in comparison to herbicide glyphosate (1.8 kg · ha–1). The report showed that all of the five compounds performed well in the control of the water hyacinth. As reported by other research findings, the efficacy increased as the concentration was increased from 10 to 20%. With formic and propionic acids, the plants died earlier than when the other acids or the herbicide glyphosate, were used. Acetic acid came after formic and propionic acids in terms of efficacy. Citric acid ranked last (El-Shahawy 2015). In cases of our research on acetic acid the finding was in line with what other researches had indicated. The conventional herbicides could probably replaced by widely use of these chemicals in the future. These chemicals are perceived as environmentally benign for their rapid degradation to carbon dioxide and water (El-Shahawy 2015).

The use of aquatic plants for water and waste water treatment is increasing nowadays (Abinaya et al.2018). The phytoremediation potential of water hyacinth was examined for the removal of Total dissolved solids (TDS) from second stage RO brine solution of textile dying industry by attached growth shallow pond system (Abinaya et al.2018). The nutrient limitation in lakes and for any aquatic ecosystem has previously received more study than that in estuaries, and determined by biochemical processes as denitrification, preferential sedimentation of nitrogen in zooplankton fecal pellets (Howarth et.al. 1988). Factors regulating phytoplankton production and standing plant in the world's freshwaters was studied by D.W. Schindler and reported that the proportion appears to vary greatly from lake to lake, probably as a result of differences in morphometry, drainage basin characteristics, and types of consumer organisms, as well as productivity differences (Schindler, D. W. 1978).

In their study the Recovery of acid damaged zooplankton communities: measurement, extent, and limiting factors Gray and Arnott (2009) indicated that Studies conducted in eastern North America and Northern Europe have demonstrated significant, though often incomplete, recovery of zooplankton communities in lakes that reach a pH > 6.0. Zooplankton recovery in acidified regions indicates that recovery of affected communities is still not complete, even for lakes that have chemically recovered. Although adequate water quality is vital for community recovery, long-term studies have detected a delay in zooplankton recovery for 3–10 years, even after water quality has reached acceptable levels (pH > 6.0; Keller and Yan 1998; Yan et al. 2003; Frost et al. 2006 cited by Gray and Arnott (2009).

The roots of Water hyacinths (WH) naturally absorb pollutants including lead, mercury, and strontium-90, WH can be cultivated for waste water treatment and it can be used to aid the process of water purification either for industrial waste water or sewer water, in addition to available techniques (Magar, R., Khan, A. N., and Honnutagi, A. (2017).

Effects of water hyacinth on water quality of winam gulf, lake Victoria was studied by Osumo (2001) and reported that the oxygen levels in the gulf were found to increase significantly (2-4 mg/l) after the destroy of the hyacinth. Temperature determines the density of water and therefore determines the stratification and thus affects vertical mixing in the water column. This will affect the distribution of many properties such as oxygen (Osumo 2001). In his finding Osumo (2001) also indicated that dissolved oxygen was comparatively lower when water hyacinth organic matter was being dumped in the lake by the mechanical shredding of water hyacinth in July than it was in March, due to the decomposition of water hyacinth organic matter by bacteria.

In conclusion, **t**he efficacy of acetic acid on water hyacinth control was increased when its concentration increased from 5 to 20%. Spraying 20% concentration of acetic acid resulted in entire damage (100%) on the stem, stolen and leaf part of the water hyacinth, followed by 15% whereas the application of 10% concentration of acetic acid suppressed the growth of water hyacinth, however, it permitted the production of few new daughter plants for further infestation and needs subsequent sprays, while 5% was less effective. Subsequent decay of water hyacinth plant parts were found to affect some parameters of water quality negatively and decreased zooplankton and phytoplankton abundance. However, all concentrations of the treatments did not affect the survival of all the Nile tilapia fish species throughout the experimental period.

Currently, no inorganic herbicides are used in controlling water hyacinth on Lake Tana, Physically removed water hyacinth often regenerate, flower, and set seed in ex-situ, resulting in the enhanced seed bank of the water hyacinth in the aquatic environment and its vicinities. Ex-situ application of the 20% acetic on physically removed water hyacinth in the vicinity of the lake may help to prevent regeneration of the weed. Therefore, using a 20% concentration of acetic acid was recommended for controlling water hyacinth as an eco-friendly component of integrated water hyacinth management, whereas spraying 15% and 10% acetic acid concentrations needs further studies to determine the frequency of spray for effective control of water hyacinth.

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