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# Assessment of soil chemical properties through application of fresh aquatic weeds

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## Abstract

Soils from Bajoa soil series (Typic endoequepts) were placed in pots for aquatic weeds application and to analyze chemical parameters (pH, EC, N, P, K, S, organic matter) of the treated soil. Three aquatic weeds were selected; those are Water hyacinth (Eichhomia crassipes), Water lettuce (Pistia stratiotes) and Water spinach (Ipomea aquatica). All the chemical properties were found improved for the treatment T3 (water spinach; 3000kg hac-1) and T4 (water spinach; 2000 kg hac-1) and most of the attributes were found as minimum for control. The macro nutrients such as N, P, K, S, are improved in the soil by the application of aquatic weeds as green manure because green manure plant creates more acidic condition which extracts more nutrients from fixed position in soil to bio-available form by root exudation.

**Keywords:** Bajoa soil series, Aquatic weeds, Green manure, Chemical properties of soil.

## Introduction

The menace of aquatic weed has become a crisis in many parts of world. Subsistence farmers in the wet lowlands of Bangladesh annually face disaster while the rafts of aquatic weeds are floated over their rice paddies by flood waters.[1] Aquatic weeds are those unwanted plants which grow and complete their life cycle in water and cause harm to aquatic environment directly and to related eco-environment relatively.[2] The main harmful effects of aquatic weeds are: It reduces water storage capacity in reservoirs, tanks, ponds etc; impedes water flow and water availability in canals and drainage systems; reduces fish production interferes with navigation and aesthetic value of water and promotes habitat for mosquitoes etc. There is only two ways to reduce infestation- application of herbicides and mechanical harvesting. Both are expensive and many developing countries have to spend scarce foreign exchange to import them. As warm weather supports perfuse growth of aquatic weeds, it is prominent in tropical and sub-tropical region and it is a great problem in Bangladesh and should be managed.

Aquatic weeds constitute a free crop of great potential value: a highly productive crop that requires no tillage, fertilizer, seed or cultivation. They have potential for exploitation as animal feed, human food, soil additives, fuel production and watershed treatment.[1] Mineral (inorganic) fertilizers are too expensive for farmers in developing countries, yet there is a greater requirement to increase food production. The food and Agricultural Organization (FAO) has stressed that mineral fertilizers seem harmful to soil ecosystem. Thus there is the urgency to reassess organic fertilizers, which include green manuring and composting. All these process can be use as a source of manure.[3] The presence of a large quantity of unwanted plants needed to find prudent economic use to convert a nuisance into beneficial product at low cost andlabour-intensive venture. Weeds (semi aquatic and terrestrial) may divert between 20 to 75 percent of soil nutrient and moisture meant for main crop rice.[4] Algae and aquatic weeds can be used as a source of organic matter and plant nutrients for wetland rice.[5] In accordance of consideration of the above-discussed factors, this study was undertaken to determine some chemical properties of soil through application of fresh aquatic weeds and to assess whether the weeds can be used as bio-fertilizer or source of nutrients.

## Materials and Methods

### Collection of soil sample

Soil sample was collected by proper method from field and kept in 21 one pots for experiment. Geographically the sampling site is located at Jalma union, Batiaghata upazila at 22°47' N latitude and 89°35' E longitude and was situated in Ganges Tidal floodplain area (AEZ-13).[6]

### Preparations of soil sample pot experiment

The soil was stored for about 2 weeks before sieving (4 mm) and mixed it extensively with a shovel in 21 pots. Pots were filled to 14 cm of the top and soil moisture was maintained at field capacity (0.33 g water g soil-1) by weighing individual pots and replacing lost water when necessary and room temperature was maintained in the pots.

### Pot experiment

A long-term pot experiment was initiated at the Soil Science Discipline, Khulna University, Khulna, Bangladesh in February, 2013. It was laid out with six treatments including a control experiment. Each experiment was carried out in three pots as replication to avoid experimental error. Total pot number was twenty one because seven treatments with three replications were conducted and pots were designed as completely randomized design (CRD) for statistical analysis.

### Weed selection

Three aquatic weeds were selected; those are Water hyacinth (Eichhomia crassipes), Water lettuce (Pisti astratiotes) and Water spinach (Ipomea aquatica). Which are the most common aquatic weeds of Bangladesh and widespread throughout the country.

### Application of aquatic weeds in soil

Selected three fresh aquatic weeds were incorporated in soil. Before incorporation aquatic weeds were cut into small pieces and measured following the treatments by an electrical balance to ensure nutrient release. The aquatic weeds were thoroughly mixed to the soil by a shovel; soils were watered daily (same amount of water from the same source) for hastening decomposition and were kept for six months for proper decomposition.

### Treatment of the investigation

Seven treatments including control were conducted in the experiment as,

T0 = Control; T1 = Water hyacinth in soil (3000 kg hac$^{-1}$); T2 = Water hyacinth in soil (2000 kg hac$^{-1}$); T3 = Water spinach in soil (3000 kg hac$^{-1}$); T4 = Water spinach in soil (2000 kg hac$^{-1}$); T5 = Water lettuce in soil (3000 kg hac$^{-1}$); T6 = Water lettuce in soil (2000 kg hac$^{-1}$)

### Collection of treated soil

After 6 months the color of the soil was changed and there was not a portion of fresh plants that means the aquatic weeds were completely decomposed. Then the soil samples were collected by proper method from each pot for laboratory analysis. Similarly samples were collected from control experiment pots for the same analyses.

### Preparation of soil for chemical analysis

The collected soil samples were air dried by spreading on separate sheet of papers after it was transported to the laboratory. After drying in air, the larger aggregates were broken gently by crushing it by a wooden hammer. A portion of the crushed soils was passed through a 2.0 mm sieve. The sieved soils were then preserved in plastic bags and labeled properly. These were later used for various chemical analyses. The chemical analyses of these collected soil samples were carried out in the laboratory of the Soil Science Discipline, Khulna University.

### Laboratory analysis

Soil pH was determined electrochemically with the help of glass electrode pH meter as suggested by Jackson.[7] The ratio of soil to water was 1:2.5 as suggested by Jackson.[8] The electrical conductivity was measured at a soil: water ratio of 1:2.5 by the help of EC meter .[9] Organic carbon of soil samples was determined by Walkley and Black's wet oxidation method as outlined by Jackson.[8] Organic matter was calculated by multiplying the percent value of organic carbon with the conventional Van-Bemmelene's factor of 1.724.[10] Total nitrogen of the soils was determined by Micro-Kjeldahl's method following $H_2SO_4$ acid digestion method as suggested by Jackson.[11] The available K was determined from $NH_4OAc$. (PH, 7.0) extract as described by Jackson.[11] The extract was analyzed for available K by a flame analyzer at 589 nm. Available Phosphorus was extracted from the soil with 0.5 M $NaHCO_3$ (Olsen's Method) at pH 8.5 and Molybdophosphoric blue colour method of analysis was employed for determination of phosphorus[11] and Available sulfur content was determined by turbidimetric method as described by Jackson.7 It was measured by spectrophotometer at 420 nm.

### Statistical Analysis

In this study, data were subjected to a one factor (different aquatic weed treatment) analysis of variance (ANOVA) to determine if the materials mineralized differently with several aquatic weed with F test at 5% level of significance with the statistical package of MINITAB.

## Results and Discussion

Seven replicated soil samples including control were analyzed to determine the chemical properties in the laboratory. After analyzing the results are discussed below.

**Table 1:** Different chemical properties of studied soil at field capacity (0.33 g water g soil-1) soil condition.

| Sample | pH | EC (dS $m^{-1}$) | OM % | OC % | Total N (%) | Available P (µg $g^{-1}$) | Available K (µg $g^{-1}$) | Available S (µg $g^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| $T_0$ | 8.5 | 6.8 | 2.68 | 1.56 | 0.15 | 5.17 | 108.39 | 106.67 |
| $T_1$ | 8.2 | 7.1 | 2.87 | 1.67 | 0.16 | 5.41 | 127.55 | 126.27 |
| $T_2$ | 7.9 | 7.0 | 2.86 | 1.66 | 0.16 | 5.57 | 131.38 | 193.56 |
| $T_3$ | 7.6 | 6.9 | 2.89 | 1.68 | 0.16 | 7.36 | 135.21 | 214.18 |
| $T_4$ | 8.1 | 6.9 | 2.99 | 1.74 | 0.17 | 8.68 | 135.21 | 240.68 |
| $T_5$ | 7.5 | 7.2 | 2.72 | 1.58 | 0.16 | 5.85 | 131.38 | 108.51 |
| $T_6$ | 7.7 | 7.3 | 2.75 | 1.60 | 0.16 | 6.19 | 131.38 | 120.11 |

Here, T1 =water hyacinth (3000 kg $hac^{-1}$), T2 =water hyacinth (2000 kg $hac^{-1}$), T3 =water spinach (3000 kg $hac^{-1}$), T4 =water spinach (2000 kg $hac^{-1}$), T5 =water lettuce (3000 kg $hac^{-1}$), T6 =water lettuce (2000 kg $hac^{-1}$) and T0=control

### pH

Aquatic weeds induces acidity by incorporating organic matter i.e. pH become lower except when counterbalances by high concentration of basic cations.[12] The pH under the study ranges from 7.5 to 8.5 which indicate that the soils are slightly alkaline.[13] The average pH value of experiment T0, T1, T2, T3, T4, T5 and T6 were 8.5, 8.2, 7.9, 7.6, 8.1, 7.5, 7.7 respectively (Table. 1). The highest value was 8.2 for T1 and lowest value was 7.5 for T5 by the application of fresh aquatic weeds (Fig. 1). Aquatic weed incorporated organic matter in the soil which produces organic acids.[13] So, the pH decreases. Soils with pH 7 to 8.3 is in a range that promotes microbial activity, but limits phosphorous (P), iron (Fe), manganese (Mn), copper (C) and zinc (Zn) availability at toxic level and helps to increase availability of these nutrients under alkaline conditions.[14] Different fresh aquatic weeds and control experiment were statistically significant at 1% level of significance.

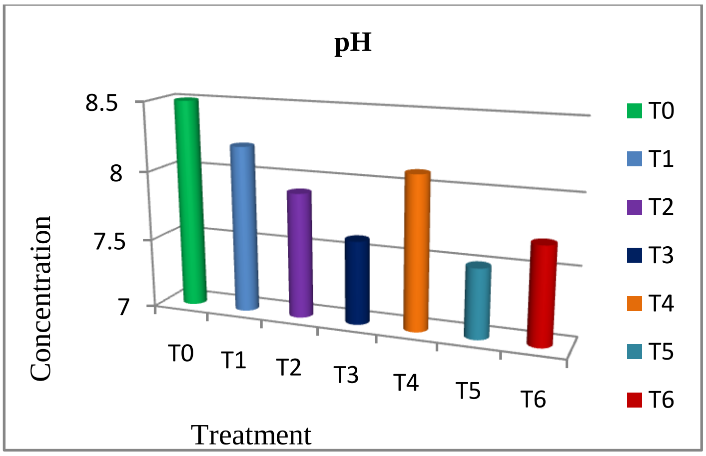


**Figure 1:** Variation of pH of the soil samples for using different fresh aquatic weeds to the soil

**Electric Conductivity (EC)**

In the experiment, 6.8 dS m-1 EC was found in control, T0. EC for treatment T1, T2, T3, T4, T5 and T6 were found 6.9, 7.0, 7.1, 6.9, 7.2, 7.3dS m-1respectively (Table.1). The maximum value of EC was 7.3 dS m-1for treatment T6 and minimum value was 6.9 dS m-1for treatment T1 and T4 (Fig. 2). During the experiment local saline water was used for irrigation. So, both saline water and application of fresh aquatic weeds increased the EC value of experimental soil. Application of fresh aquatic weed as green manure without nitrogen factor increases soil EC 2% (dS m-1). There was significant variation of EC of the soil samples after applying different fresh aquatic weeds at 1% level of significance.

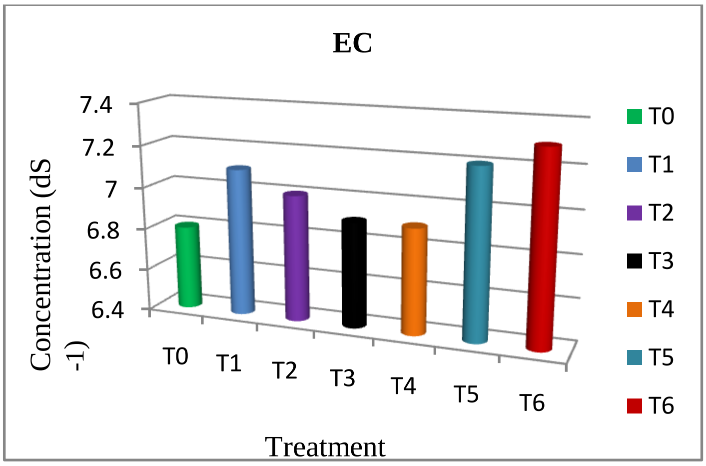


**Figure 2:** Variation of Electric conductivity of the soil samples for using different fresh aquatic weeds to the soil.

**Organic Matter (OM)**

The percent organic matter content of treatment T0, T1, T2, T3, T4, T5 andT6 were found 2.68 %, 2.87 %, 2.86 %, 2.89 %, 2.99 %, 2.72 %, 2.75 % respectively ( Table. 1). The content of organic matter from treatment T1 was highest and the lowest value was observed in treatment T5 (Fig. 3). The treatment of different aquatic weeds and control experiment were statistically significant at 1% level of significance. Sahai (1999) noted that decomposition of increased biomass results in more organic matter.[15] In the experiment the amount of OC and OM has been increased for the application of fresh aquatic weeds to the soil because aquatic weed adds biomass in soil.

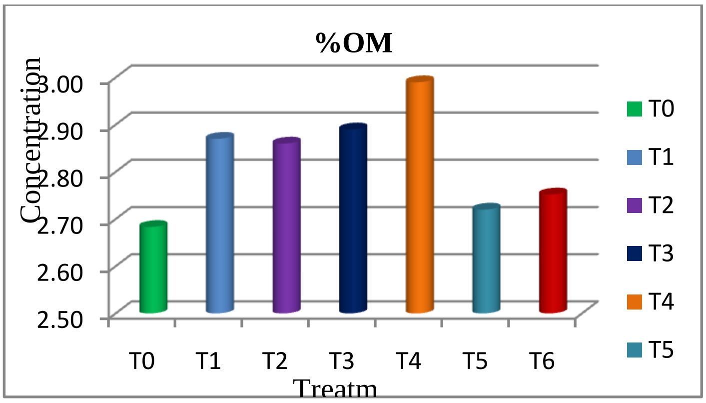


**Figure 3:** Variation of Organic Matter (OM) of the soil samples for using different fresh aquatic weeds to the soil

**Total Nitrogen (N)**

The total nitrogen content of the control experiment, T0 was found an average value of 0.15%. The total nitrogen content of T1, T2, T3, T4, T5 and T6 was indicated an average value 0.16 %, 0.16 %, 0.16%, 0.17 %, 0.16 %, 0.16% respectively (Table 1). The range 0.181 % to 0.27 %, 0.091 % to 0.18 %, <0.09 % indicates medium, low and very low percentage of nitrogen respectively.[13] In the experiment the total N content are increased in same level for treatment T1, T2, T3, T5 and T6 (Fig. 4). The maximum level of total N was increased by treatment T4 (0.17%) (Fig.4).

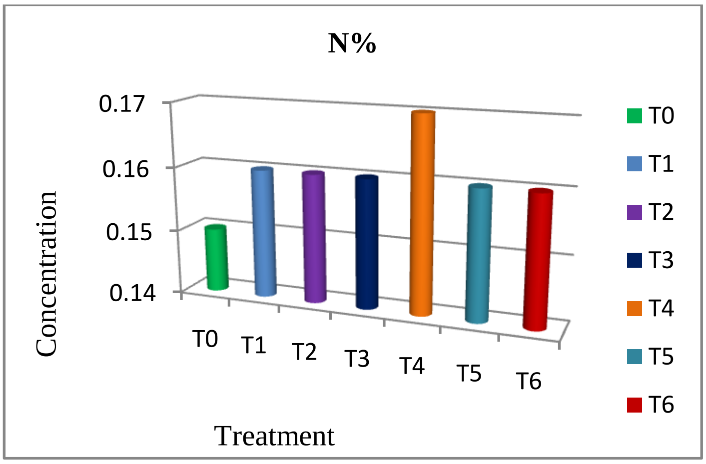


Figure 4: Variation of the total nitrogen (N) of the soil samples for using different fresh aquatic weeds to the soil

The release of nitrogen from green manure depends on state of decomposition and lignin percentage.[16] So water spinach has low percentage of lignin and its decomposition rate is high. Green manuring by aquatic weed added fresh organic matter in soil which contributes nitrogen to the soil.[17] From the statistical analysis there was a significant variation of total nitrogen of the soil samples after applying different aquatic weeds at 5% level of significance.

### Available Phosphorous (P)

In the experiment average 5.17 µg g-1, 5.41 µg g-1, 5.57 µg g-1, 7.36 µg g-1, 8.64 µg g-1 , 5.85 µg g-1 and 6.19 µg g-1 phosphorus in soil were observed by treatment T0,T1,T2, T3, T4, T5 andT6 respectively (Table.1). The maximum value was 8.68µg g-1 for T4 and the minimum value was 5.41 µg g-1 for treatment T1 (Fig. 5). The range < 7.5 µg g-1 and 7.51 µg g-1to 15.0 µg g-1 indicates very low and low percentage of phosphorus respectively.[13] Application of fresh aquatic weed created acidic environment around root zone and decreased soil pH level (Fig. 5). So, application of fresh aquatic weeds contributes phosphorus in soil than control because it increases soil phosphorus bioavailability in root zone by creating acidic environmental condition through organic acid production by organic matter decomposition. Different aquatic weed treatments and control experiment were statistically significant to at 1% level of significance.

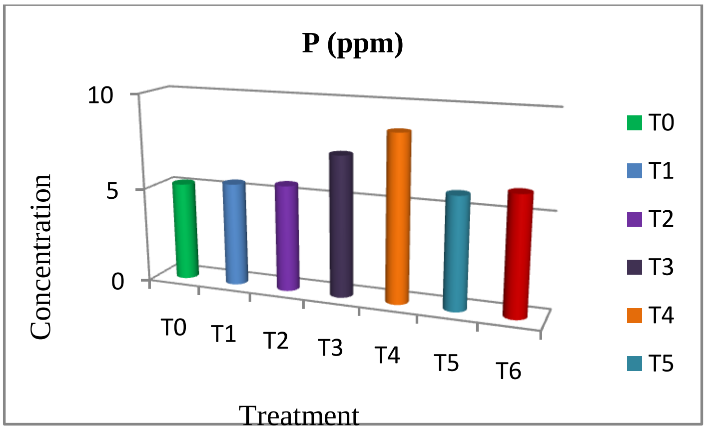


**Figure 5:** Variation of the availability of Phosphorous (P) of the soil samples for using different fresh aquatic weeds to the soil.

### Available Potassium (K)

In this experiment, the amount 108.39 µg g-1 available K was found in T0 (control) experiment. On the contrary, the value of available K was observed 127.55 µg g-1 for T1, 131.38 µg g-1 for T2, 135.21 µg g-1 for T3, 135.21 µg g-1 for T4 ,131.38 µg g-1 for T5 and 131.38 µg g-1 for T6 (Table 1). So the application of aquatic weeds to the soil increase the availability of K to the soil and it is proved by comparison with the control experiment. The availability of K in the soil varied for using different aquatic weeds in different rate it was lowest for T1 and highest availability was for found for the utilization of T3 and T4 to the soil (Fig.6).

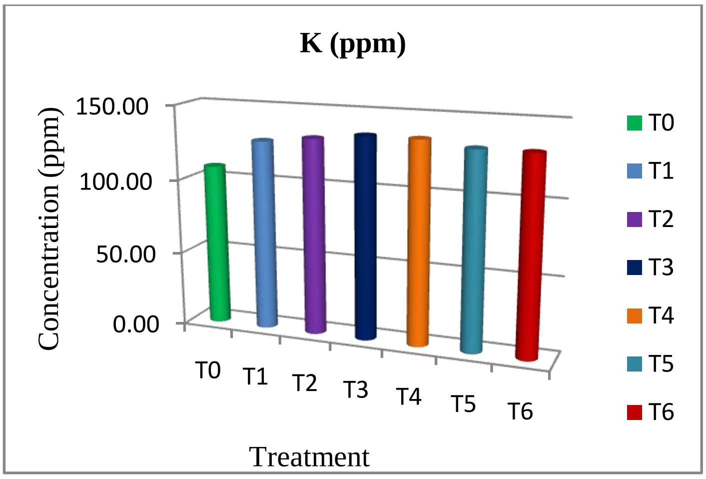


**Figure 6:** Variation of the availability of potassium (K) of the soil samples for using different fresh aquatic weeds to the soil

Different aquatic weed treatment and control experiment were statistically significant so there was a significant relationship among the available P contents in the soil samples at 5% level of significance. Aquatic weed releases K+ form by organic matter decomposition. The range 0.271 to 0.36 meq/100g (10.596 to 14.076 ppm) and 181 to 0.27 meq/100g (7.077 to 10.557) indicates optimum and medium potassium respectively.[13]

### Available Sulfur (S)

Seven treatments including control were conducted. The average S content of T0 (control) treatment was found 106.67 µg g-1. On the other hand, the amount of available S was found 126.27 µg g-1 for T1 treatment, 193.56 µg g-1 for T2 treatment, 214.18 µg g-1 for T3 treatment, 240.68 µg g-1 for T4 treatment, 108.51 µg g-1 for T5 treatment and 120.11 µg g-1 for T6 treatment (Table.1). In this experiment the availability of S moderately increased in comparison with control experiment (Fig. 7). Application of fresh aquatic weed increases organic matter, so it obtains more sulfur in sulfate form. The addition of organic matter by adding fresh aquatic weed improves sulfate from sulfur content, depending on the composition and source of the organic.[18] If the available S is 30.1 to 37.5 µg g-1 in soil, it indicates high level.[13] In the experiment the availability of S is in extreme level in control treatment and increased highly with weed treatment. From statistical analysis, there was a significant difference between aquatic weed treatment and control at 1% level of significance.

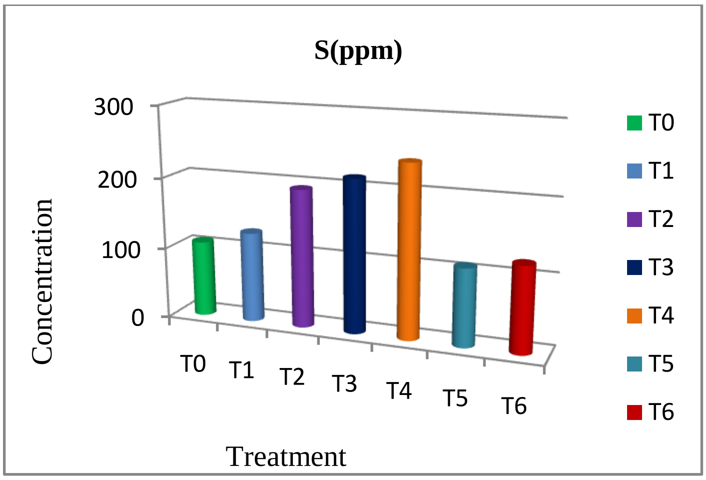


**Figure 7:** Variation of the availability of sulfur (S) of the soil samples for using different fresh aquatic weeds to the soil

## Conclusion

Macronutrients especially N, P, K, S, soil organic Carbon, Organic matter and physicochemical properties of soil pH and EC varied in the soil for different treatments. Aquatic weeds are organic substances, after incorporation to the soil the amount of organic carbon and organic matter was increased and ultimately increased the values of soil nitrogen. So, aquatic weeds can be used as a source of Organic carbon, Organic matter and Nitrogen. It can be used as an alteration of chemical fertilizer which will reduce the production cost. On the other hand decomposition of organic substances releases organic acids and decreases soil pH. In the experiment the pH level of soil was decreased thus the availability of Phosphorus also increased. Application of fresh aquatic weeds increased the EC level. It is also caused by application of saline water for irrigation. The soil Sulfur and Potassium level are also increased. So, it is recommended to use aquatic weed instead of chemical fertilizer to avoid toxic effect on human health and the findings give belief to the idea of utilizing aquatic weeds for economic benefits such as soil additives.

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