Extraction of Plant Nutrients from Freshwater Algae and their Role in Sustainable Agriculture

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A R T I C L E   I N F O
A B S T R A C T

Different types of macro- and micronutrients are required by agricultural and horticultural plants for their growth and development. Unfortunately, due to some natural phenomenon and also nutrients depletion. This results in abnormal growth and development of the plant. The earlier solution such as chemical inorganic nutrients used to eradicate this weakness has itself turned into a toxic affecting not only the environment but also the consumers. Alternatively, Algae, a simple, aquatic plant-like organism possessing extraordinary biological features is capable to not only remediate the lack of nutrients in plants but also promote organic farming while increasing the yield. Thus they constitute an ultimate alternative solution in agriculture. Such plant nutrients can be isolated from various kinds of freshwater and seawater algae in an economic manner. The present review aims at enlightening the whole process of obtaining plant essential nutrients from algae and hence the formulation of a potential biofertilizer with these active nutrients without the need of microorganisms and inorganic nutrients. The development of this kind of product could help curtailing the use of chemical fertilizers and thereby improving the health of the environment as well as consumers. 

Such a preparation requires the use of suitable microorganisms capable to decompose the preparation and free the nutrients. While in terms of fertilizer, organic means a product that has been minimally processed and the nutrients remain bound up in their natural forms rather than being extracted. Organic fertilizers also require microorganisms to break down the compost or manure before releasing the organic nutrients to the plant. The decomposition of the compost depends on the microorganisms present in the soil; the type as well as the quantity. This may delay the release of nutrients and hence the growth and development of the plant. The examination of the limitations of both chemical and organic fertilizers gives sense to this current review.

Freshwaters are diverse due to several factors including but not limited to salinity, size, depth, transparency, nutrient conditions, pH, and pollution. This diversity causes high variation in the nutritional composition of algae found in these environments. The salinity level of freshwater is less compared to brackish water as well as seawater. The latter contains the highest level of salt.

A study on micro and macronutrients status of the cyanobacteria Arthrospira platensis, cultured in brackish water and freshwater showed that macronutrients were highly present in brackish water Arthrospira platensis and lesser in freshwater Arthrospira platensis, while

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micronutrients present in freshwater *Arthrosira platensis* were higher compared to that found in brackish *Arthrosira platensis* (Puganeswary *et al*., 2014).

Although there is no typical division of freshwater algae, but some groups of algae are abundantly present in freshwater. For instance, blue green algae or Cyanobacteria, green algae or Chlorophyta, and Charophyta (Wher and Sheath, 2002).

Algae are simple autotrophic and photosynthetic organisms having no differentiation into their roots, stems, and leaves. They occur in various shapes and sizes and have different ecological roles. Thousands of species of algae occur worldwide in both fresh and marine water. The major types of algae found in freshwater are blue green algae or Cyanobacteria, green algae or Chlorophyta, Euglenoids or Euglenophyta, yellow green algae or Xanthophyta, Dinoflagellates or Dinofyta, Cryptomonads or Cryptophyta, Cryosphytes or Cryophyta, Diatoms or Bacilloraphyta, Red algae or Rhodophyta, and Brown algae or Phaeophyta. All these above freshwater algae have several biochemical characteristics but the major features are pigmentation, external covering and food reserve. The pigments involved are chlorophylls, cartenones, and phycobilins. Chlorophyll a is present in all pigmented freshwater algae and serves as a target for the estimation the total biomass content (Bellinger and Sigee, 2010).

Freshwater algae contain important amount of plant nutrients attached to their major biochemical components. Beyond these nutrients, metabolites such as carbohydrates and proteins as well as plant growth regulators are also present (Haroun and Hussein, 2003). The micro and macronutrients composition of freshwater algae can be extracted and then estimated.

Due to their several potentialities, algae are widely used in number of industries to commercially produce useful end products such as foods, pharmaceuticals and medicines, animal feeds, and fuels.

Presently algae are used mostly in two ways in agriculture. The first is a biofertilizer in which algae are used in symbiosis with microorganisms in the form of inoculums; the second consists of combining the algal extract with inorganic nutrients in suitable ratios. The uses of microorganisms and inorganic nutrients show a convergent target. This target is to make the nutrients readily available to the plant in order to speed up their uptake and hence fasten the growth of the plant.

For a sustainable agriculture, it is smarter to extract these nutrients in suitable ratios in form of bioactive nutrients from a replenishable and fast growing source such as freshwater algae. In this case inorganic nutrients and microorganisms are not necessary. This review classifies the uses of algae in agriculture along with the whole procedure of obtaining bioactive nutrients from them.

**Plant nutrition**

**Plant nutrients, role, and deficiency symptoms**

**Macro-elements- Primary Nutrients**

Nitrogen (N), Phosphorus (P) and Potassium (K) form the primary nutrients of the macro-elements. They are usually called NPK and are consumed in large quantity into the plant tissue. The amounts range from 0.15 to 6.0 % of the dry matter. They should be readily available to plant. Nitrogen is the most important of all nutrients. It constitutes one of the four mains components (carbon, hydrogen, oxygen, and nitrogen) of plant. Also it is the main component of protein, DNA, and chlorophyll of plant. Thus it is involved in photosynthesis (Mills *et al*., 1996).

**Secondary macronutrients:**

Secondary nutrients are Sulfur (S), Calcium (Ca), and Magnesium (Mg). They are also required in higher quantities but relatively lesser than primary nutrients. These nutrients may be easily obtained from soil, but the use of fertilizer may help in boosting the yield (Mills *et al*., 1996).

**Micronutrients:**

Micronutrients are Zinc (Zn), Iron (Fe), Boron (B), Chlorine (Cl), Manganese (Mn), Copper (Cu), Sodium (Na), Cobalt (Co), Molybdenum (Mo), Silicon (Si), and Vanadium (V). These micronutrients are absorbed in lesser quantity into the plant tissue. The required amounts of micronutrients in the plant tissue range from 0.15 to 400 ppm (parts-per million). Micronutrients are also found at the site of metabolic enzymes of plants, thus involved in plant metabolism (Mills *et al*., 1996).

**Importance of Algae in Agriculture**

With the rise in human population, it is becoming imperative to focus on sustainable agriculture.

The use of algae as source of fertilizer is an alternative and sustainable way to improve agriculture without affecting human health and environment but rather increasing the productivity of the plant and the fertility of the soil. Three major classes of algae that are mostly used in agriculture are Cyanobacteria or Blue Green Algae, Brown macroalgae, and Red macroalgae (Chatterjee *et al*., 2017). Almost, all algae species used in agriculture come from these three classes.

**Blue Green Algae (BGA) or Cyanobacteria:** Species of cyanobacteria that are mostly involved in agriculture are as follow: Anabaena, Anabaenopsis, Aphanothece, Aulosira, Calothrix, Camptophyta, Chlorogloea, Chlorokleopsis, Cylindrospermum, Fischereilla, Gloeotrichia, Hapalosiphon, Mastigocladus, Nodularia, Nostoc, Nostochopsis, Plectonema, Rivularia, Schytonematopsis, Scytonema, Stigonema, Tolypothrix, Westiella, Westiellopsis, and Wollea cyanobacteria (Chatterjee *et al*., 2017) (Prakash *et al*., 2014); (Sukumaran *et al*., 2014). Cyanobacteria species are probably the most widely used algae for fertilization. More than 25 species of cyanobacteria are used as biofertilizer. BGA have the potentiality of fixing 18-45 Kg of nitrogen (N) per hectare in a submerged rice field. In addition, they produce growth promoting substances (Chatterjee *et al*., 2017).

Cyanobacteria or BGA play an important role in the improvement and stability of soil aggregation and in the porosity of soil. The aggregation of soil is important for the improvement of the physical environment of the crops. For instance, when used on silt loam salt, BGA increases the activities of certain substances such as urease, dehydrogenase, polysaccharide, and phosphatase which ultimately lead to an increase in soil aggregation and its water holding capacity. With regard to the porosity, some Cyanobacteria species like *Nostoc* has the ability to solubilize insoluble inorganic phosphate and other organic matter including nitrogen present in the soil. Certain trace elements such as Fe, Mn, Zn, Co, Mo and Cu, are released from insoluble
### Table - 1: Primary Nutrients, Functions and Deficiency Symptoms (Uchida, 2000).

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Available to soil as</th>
<th>Functions</th>
<th>Deficiency symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus (P)</td>
<td>Orthophosphate (HPO₄²⁻ and H₂PO₄⁻)</td>
<td>Energy storage and transfer (ADP, ATP, DPN, and TPN). Constituent of RNA and DNA. Formation of seeds and it is also largely Support the rate of metabolism and cell division. Helps in development of root, flower and seed. Reduces the disease effect in some plants. Improvement of the crop quality.</td>
<td>Slow, weak, and stunted growth. Dark to blue-green coloration on older leaves of some plants. Purpling of leaves and stems. Delayed maturity and poor seed and fruit development.</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>Potassium ion (K⁺)</td>
<td>Activation of enzyme for metabolism. Controls the opening and closing of leaf stomates. Maintaining the balance of electrical charges at the site of ATP production Translocates photosynthates. ATP and proteins synthesis. Improve the resistance to disease, grain and seed size, and the quality of plants.</td>
<td>Chlorosis. Slow and stunted growth. Weak and lodging crops and steams. Reduction in the size of seeds and fruits and yield.</td>
</tr>
</tbody>
</table>

### Table - 2: Secondary Nutrients, Functions and Deficiency Symptoms (Uchida, 2000).

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Available to soil as</th>
<th>Functions</th>
<th>Deficiency symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium (Ca)</td>
<td>Calcium ions (Ca²⁺)</td>
<td>Formation of the cell wall membrane and its plasticity, Activator of several enzyme systems during protein synthesis and transfer of carbohydrate. Detoxification of the plant. Production of seed in peanuts. Reduction of acidity of soils, when they are lime</td>
<td>Brown coloration and death of the plant. Limitation in growth, Tearing and unfurl of growing leaves, and Weak structure of the stem. Cupping and Crinkling of leaves Deterioration of the terminal bud.</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>Magnesium ions (Mg²⁺)</td>
<td>Constituent of chlorophyll molecule thus involved in Photosynthesis. Co-factor in several enzymatic reactions enabling the activation of the processes of phosphorylation. Stabilization of ribosome particles and the structure of nucleic acids. Assists the movement of sugars within plant</td>
<td>Occurrence of chlorosis in older leaves. Drop of younger leaves</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>Sulfate ions (SO₄²⁻)</td>
<td>Constituent of certain amino acids. Participates in the metabolism of B vitamins biotin and thiamine and co-enzyme A. Formation of chlorophyll nodule in legumes, and protein structure stabilization</td>
<td>Chlorosis in both younger and older leaves. Retardation of growth rate. Thin, stiff, and woody plant stems.</td>
</tr>
</tbody>
</table>
**Table - 3: Micronutrients, Functions and deficiency symptoms (Uchida, 2000).**

<table>
<thead>
<tr>
<th>Nutrients</th>
<th>Available to soil as</th>
<th>Functions</th>
<th>Deficiency symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron (B)</td>
<td>Borate (H3BO3)</td>
<td>Involved in RNA, seed and cell wall formation, cellular and enzymatic activities, pollen germination, pollen tube growth, lignin synthesis and in root growth promotion.</td>
<td>Stunted growth, thickened, curly and brittle leaves, hollow and black hearts, crooked and cracked stem, distorted and lumpy fruit, calyx splitting, midribs crack, brown colour (in Chinese cabbage), and pith in hollow stem.</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>Ion Cu++</td>
<td>Synthesis of chloroplast protein plastocyanin, Stability of chlorophyll and other pigments.</td>
<td>Reduction in growth, distortion of the younger leaves, necrosis in the apical meristem, bushy appearance in trees, bleaching in young leaf, defoliation and dieback of twigs, stunted and chlorotic plant.</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>Fe2+ Fe3+</td>
<td>Photosynthesis and respiration Part of protein ferredoxin Nitrate and sulfate reductions. Synthesis and maintenance of chlorophyll in plants.</td>
<td>Interverinal chlorosis in younger leaves. Chlorophyll production</td>
</tr>
<tr>
<td>Chlorine (Cl)</td>
<td>Chloride ion (Cl-)</td>
<td>Evolution of oxygen during photosynthesis, Increases osmotic pressure of the cell and the water content of plant tissues. Fights against fungal diseases</td>
<td>Chlorosis in younger leaves and wilting of the plant.</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>Zn ++</td>
<td>Synthesis of tryptophan, metallo-enzymes, Activation of carbonic anhydrase, RNA and protein synthesis.</td>
<td>Interverinal chlorosison Stunted growth, Reduction in fruit formation.</td>
</tr>
<tr>
<td>Molybdenum (Mo)</td>
<td>Molybdate (MoO4)</td>
<td>Component of both the enzymes nitrate reductase and nitrogenase necessary for the assimilation of N in during nitrogen fixation.</td>
<td>Chlorosis in older and middle leaves, Stunted plant, Restriction in flower formation.</td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>Mn²⁺, Mn³⁺</td>
<td>Involved in the primary function of metabolism as a part of plant enzyme system, pyruvate carboxylase formation, oxidation-reduction process during photosynthesis, indole acetic acid oxidase activation.</td>
<td>Chlorosis in young tissues.</td>
</tr>
</tbody>
</table>
materials to the soil by Cyanobacteria. Also, they release exoplysaccharide which have the properties to foster the growth of microbes leading to better soil structure (Abdel-Raouf et al., 2012).

Plant growth regulators such as vitamins, amino acids, antifungal, polypeptides, and antibacterial substances are produce by Cyanobacteria. These substances influence the growth and development of the plant. In addition, BGA not only fasten the germination of seeds to promote their growth (including higher plants) but also increase the protein content of these seeds and their yield. Nutrients in form of bioactive substances are released by BGA to the plant and they also defend plants against biological attackers. Plant growth hormones including cytokinin-like substances, auxin-like substances, gibberellic-like substances antibiotics, algicide, toxins, organic acids, and even some pharmaceutical active compounds are produced by Cyanobacteria. These hormones instigate the direct growth of the plants. When used in plants such as rice, lentil, wheat, sorghum, maize and tomato BGA biofertilizer, increase significantly the germination rate, the growth, shoots and root length, and vitamin C content in Tomato.

**Brown Macrogalae**: Species of brown algae that are mostly involved in agriculture are as follow Marginatum, Ecklonia maxima, Laminaria digitata (Oarweed), Fucus vesiculosus (Bladder wrack), Ascophyllum nodosum (Knotted wrack), and Stoechospermum (Chatterjee et al., 2017). These algae are commonly rich in nutrients such nitrogen (N), phosphorus (P), and potassium (K) (Chatterjee et al., 2017). In contrast, the micro elements analysis of a brown algae S.polycystum by (Bharath et al., 2018) showed lesser result in potassium content (6.81 mg/L) while elements such as sodium, chloride, and calcium show higher result respectively 85.3 mg/L, 75.02 mg/L, and 69.37 mg/L. In addition, when brown algae are used in clay soils, they release carbohydrate to ameliorate the structure and aeration of clay soils. Brown algae are also presented as a good source of plant growth regulators and hormones such as auxin, gibberellins and cytokinin. All these substances provide good health and increase the yield crops. They increase the freezing, drought, and

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Roles</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>Strong alkali pH reduces the surface tension, removes partially lignin, removes completely acetyl or uranic ester group of hemicelluloses and vitiates nutrients and endogenous material activities. Change the biochemical solubility. (Silva et al., 2015)</td>
</tr>
<tr>
<td>Time</td>
<td>Biochemical extractability Long time of extraction can lead to microbial growth and oxidation of phenolics resulting in lesser yield. (Silva et al., 2015)</td>
</tr>
<tr>
<td>Solvent</td>
<td>For promoting mass transfer in order to increase the rate of extraction Acidic solvent also extends the degradation of cell wall Minimum quantity of solvent capable to attain diffusion should be taken into account to avoid high cost Selection of solvent-algae ratio, algae-solvent ration and algae particles size are also important. (Manzoor et al., 2012)</td>
</tr>
<tr>
<td>Temperature</td>
<td>Should be in the range of 20-35oC to avoid degradation of thermolabile compounds. Higher temperature (above 40 oC) leads to degradation of lignin and at long extraction time, it decreases the yield. Biochemical extractability Increase analyte solubility Increase diffusion rate Decrease viscosity Decrease solution surface tension (Silva et al., 2015)</td>
</tr>
</tbody>
</table>

**Table - 5: Solvent extraction methods**

<table>
<thead>
<tr>
<th>Solvents</th>
<th>Products</th>
<th>Importance</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot water Booth B. et al., 1969.</td>
<td>Biostimulants rich in fucoidan</td>
<td>Enhance anti-cancer activity.</td>
<td>Should be in the range of 20-35oC to avoid degradation of thermolabile compounds. Higher temperature (above 40 oC) leads to degradation of lignin and at long extraction time, it decreases the yield. Biochemical extractability Increase analyte solubility Increase diffusion rate Decrease viscosity Decrease solution surface tension (Silva et al., 2015)</td>
</tr>
<tr>
<td>Freezed or cold water Se-Kwon Kim et al., 2015.</td>
<td>Foliar and soil suspension biofertilizers</td>
<td>Rich in plant nutrients</td>
<td>For promoting mass transfer in order to increase the rate of extraction Acidic solvent also extends the degradation of cell wall Minimum quantity of solvent capable to attain diffusion should be taken into account to avoid high cost Selection of solvent-algae ratio, algae-solvent ration and algae particles size are also important. (Manzoor et al., 2012)</td>
</tr>
<tr>
<td>Chilled ethanol (70%) + Deterium Wendy A. Stirk et al., 2009.</td>
<td>Cytokinin</td>
<td>Plant growth hormone</td>
<td>Change the biochemical solubility. (Silva et al., 2015)</td>
</tr>
<tr>
<td>Methanol Timo Hytönen et al., 2008.</td>
<td>Gibberellins</td>
<td>Plant growth hormone</td>
<td>Change the biochemical solubility. (Silva et al., 2015)</td>
</tr>
</tbody>
</table>
tolerate salt. The phosphosynthetic activity and the resistance of plants to bacteria, virus and fungi are improved by brown macroalgae. (Chatterjee et al., 2017).

**Red Macroalgae:** The most common red algae species used in agriculture are Phymatolithon calcareum (Maerla) and Lithothamnion corallioides (Maerla) (Chatterjee et al., 2017). Laurencia obtusa, Corallina elongata and Jania rubens (Safinaz et al., 2013). Red macroalgae are also widely used as biofertilizer. due to their high content of trace elements and other agricultural properties. Three red macroalgae *Laurencia obtusa, Corollina elongate*, and *Jania rubens* were investigated for their NPK values. The result showed that the nitrogen contents were respectively 0.39%, 0.34%, and 0.4%. The phosphorus (P) values were 0.38%, 0.38%, and 0.35% respectively, while the potassium (K) amounts were 0.2%, 0.16%, and 0.16% respectively. These result showed that the combination of these three red macroalgae as a biofertilizer, gave a potential increase in the growth rate and the vegetative value of maize plants. Many other articles reported that red macroalgae increase the fresh and dry weight of plants, their carbohydrate content (Safinaz et al., 2013).

Hence, algae based biofertilizer show tremendous importance in a sustainable agriculture due to their safety and their nutritional values. They could be not only a solution to combat agricultural related problems such as nutrient depletion and arid/semi arid soil, but also a mean to increase the economical value of crops and other agricultural plants. Unlike chemical fertilizers, the nitrogen and phosphorus present in detritus of dead algae can be reused as soil stabilizer and biofertilizer for crops. Such a method is beneficial in two ways, the increase in crop yield and reduction of algal density in lake (Tiwari et al., 2017).

**Collection of freshwater algae**

**Microalgae collection**

Freshwater microalgae can be collected from various sources. These sources are large and small rivers, lake, ocean, and stream.

Equipments: the collection of microalgae samples for nutritional analysis requires following materials: a pole type sampler or horse-pipe sampler, or a depth sampler. Other materials such as gloves, sample bottles, Lugol’s solution and pipette, a cool box containing ice bricks, and a bucket (5L) freshwater for washing hands and materials are also used.

Whatever the selected source or type of algae, according to the Department of environment and heritage protection (May, 2017), following procedures are preponderant in algal sample collection. It is important to select a representative site of collection for ecological surveys; all the physical characteristics of the algae present in the selected site should be noted. These characteristics might be the color, odor, presence of dead organisms or other wastes. The sample bottles should be labeled with a water proof, addition of few drops of Lugol’s solution is important to preserve the sample and finally the collected samples should be kept in a cool box containing ice bricks (Dhargalkar et al., 2004).

**Macroalgae collection**

According to British phycological society, macroalgae can be collected by hand in shallow water and by snorkeling in deeper water. Although, some materials such as glass bottomed box, three-pronged gneal or drgee can be used. After collection the sample should be squeezed in order to remove the water before storage (Dhargalkar et al., 2004).

**Extraction of active nutrients**

Extraction is a process in which two immiscible phases come into contact in order to transfer a particle from one phase to the other (Harrison et al., 2004). To facilitate extraction process and increase the yield, several of pre-treatments of algal biomass are required. These treatments are grouped into two aspects. The first consists of several washings of the collected algal sample immediately after collection, followed by drying and grinding processes. The second deals with cell disruption processes. These treatments involve several parameters that affect the efficiency, yield, cost and the type of product desired.

**Pretreatment**

**Stage 1:** The first stage of pretreatment involves washing, drying, and grinding of the algal sample.

**Washing** is the first stage of the pre-treatment processes. Algae are repeatedly washed immediately after collection in order to remove sand particles and other impurities (Thirumaran et al., 2009).

**Drying:** After washing, the samples are dried. Several methods such as sun drying, oven drying, freeze drying, spray drying, roller or drum drying, and fluidized-bed drying are used to dry algae. Drying of macroalgae can be achieved by the above first three methods (sun drying, oven drying, and freeze drying). In a comparative study on the effect of these three drying methods on the nutritional composition of the macroalgae species Sargassum hemiphyllum. It has been found that the oven and freeze dried samples showed higher ash content than that of sun dried and thus, the mineral (nutrients) content of sun dried sample were also lesser compared to others. Except the calcium content that is much higher in sun dried sample compared to oven and freeze dried samples (Chan et al., 1997). This was probably due to over exposure to air and leaching of nutrients. In other hand, the oven drying method was shown to be not only the fastest method but also the one showing higher yield of sodium (Na), potassium (K), iron (Fe), zinc (Zn), copper (Cu), manganese (Mn), and aluminum (Al) (Chan et al., 1997).

Microalgae have been dried using sun drying, spray drying, freeze drying, roller or drum drying, and fluidized-bed drying. Sun drying requires larger area even if it is not costly, while spray and convective drying methods tends to alter the nutritional composition of microalgae (Chen et al., 2015).

**Grinding and ash content:** after drying, algae are reduced into smaller size by grinding. Grinding does not affect the nutritional composition of algae except that the raise in temperature of the grinder can lead to loss of nutrients. Grinding is important because the decrease in size of algae biomass leads to an increase in surface area enabling high rate of extraction. (Wang and Chen, 2015).

The dried weight of the sample should be taken before grinding. The amount of ash obtained after grinding is directly proportional to the amount of nutrients present in the sample. Higher the weight of ash, higher the amount...
of nutrients are available. Following formula can be used to determine the amount of ash in percentage (Mazoor et al., 2012)

\[
\% \text{Ash} = \frac{\text{Mass of ash}}{\text{Mass of dried sample}} \times 100
\]

Stage 2:
The second stage of pretreatment concerns the disruption of algal cell. This process leads to an increase in the availability of bioactive compounds and is especially necessary for microalgae due to their small size. Many techniques including chemicals, mechanicals, and physicls, thermal and enzymatic are used to disrupt algal cell wall (Michalak and Chojnack, 2014).

Extraction methods:
Various methods have been used to extract nutrients from algae. These methods include microwave assisted extraction, enzyme assisted extraction, supercritical fluid extraction using CO2 as solvent, ultrasound assisted extraction and soxhlet extraction can also be used to extract active nutrients from algae. But these techniques are costly and not environment friendly due to the toxic solvent associated (Godlewksa et al., 2016).

Some conventional solvent methods are used for specific purpose. They include hot and cold water techniques, chilled ethanol (70%) extraction, and methanol extraction.

Water solvent extractions are usually more economical, environment friendly and simple process. For instance, nutrients can be extracted by boiling or soaking the sample with distilled water followed by filtration and centrifugation. These techniques have been demonstrated by (Godlewksa et al., 2016), where nutritional status of Polystipohana, Ulva, and Cladophora have been investigated. The result obtained show that the boiled extract was rich in phosphorus (P), sulfur (S), and boron (B) while the soaked extract was rich in calcium (Ca), magnesium (Mg), and iron

Nutrient analysis methods
Various methods are available for characterizing algae plant essential nutrients in algae sample. But the most common and efficient are photometric and spectroscopic methods.

Photometry methods: are used to determine phosphorus, iron, manganese, zinc, copper and sodium. The spectro-photometrical method using molybdate-vanadate technique are used to determine phosphorus, Flame photometry is used to determine potassium, while Atomic Absorption spectro-photometry (AASP) is used to quantify various nutrients such as Iron, Manganese, Zinc, Copper, and Sodium (Tipnee et al., 2015).

Spectroscopy methods: are also used in plant nutrient analysis. These methods include Atomic spectroscopy techniques such as Inductive Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) enabling the measurement of calcium and magnesium content, Flame photometry Atomic Emission Spectroscopy (F-AES) for determination of sodium and potassium content and ICP-OES or Inductive Coupled Plasma Optical Emission Spectroscopy is used to determine all bioactive nutrients present in algae sample (Szolnokia et al., 2000).

Conclusion
Various freshwater algae are rich in plant essential nutrients as well as plant growth factors. These vital substances are present in easily available raw materials called algae. The easily availability of freshwaters also could constitute a good asset to promote algae based biofertilizers. The nutritional requirement of plants for their growth and metabolism ranges from micro to macro nutrients. For an algal extract to be considered biofertilizer, should contain in minimum the primary nutrients such Nitrogen, Phosphorus, and Potassium (NPK). However all the nutrients are crucial for the growth and development of plant. Due to the nutritional variation in the types of algae; the growth, development, and yield of plant depend on the algal species chosen. The importance of algae in agriculture lies in the fact that beyond the essential plant nutrients provided, algae contain also tremendous plant growth factors capable to not only increase the economics in agriculture but also promote its sustainability. Various extraction and characterization methods are available to determine the nutritional status of algae species. The extraction processes such as water solvent extractions are environment friendly, economical and simple. Hence, more studies must be taken on the various species of available freshwater algae to determine their agricultural importance and also to ease and promote organic farming.

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