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THE POTENTIAL OF ALGAE IN AGRICULTURE, ENVIRONMENTAL CONSERVATION AND INDUSTRY IN NIGERIA.

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ABSTRACT

Algae occur as surface crusts, as free living orgnisms in water bodies and in symbiotic association with fungi in lichens. Algae occurring in these forms have potential roles in physical improvement and protection of soils, in nitrogen fixation in paddy rice cultivation and arid agriculture, in primary biomass production and in secondary production for industrial uses. They also play useful roles in reclamation and purification of polluted waters.

These potentials are discussed with special reference to Nigeria. It is argued that algae as plants may not be 'lost' to Nigeria but that their yet unexploited potentials need to be fully investigated.

INTRODUCTION

Algae are chlorophyll-bearing and predominantly thalloid plants. They are generally considered to be the group from which all the more complex cryptogams and ultimately the Spermophyta arose. They represent an assemblage of plants of distinct characteristics with the pigments chlorophyll a and B carotene common to all of them (Round, 1973; Chapman, 1975, Weier *et al* 1982). They range widely in form from tiny microscopic cells a few micrometers in size, such as *Chlorella spp* to the large seaweeds which can attain lengths of up to 80 - 90 meters.

Ecologically algae are distributed worldwide in various surfaces, soils, rocks, as epiphytes but with the majority of them being aquatic existing in either freshwater, brackishwater or marine environments. Seventy per cent of the earth's surface is covered by water and most of these are deep waters in which the only primary producers are algae. Most algae are photo-autotrophs while a few are facultative or obligate heterotrophs. Primary production by algae forms the foundation of the food chain in most aquatic environments. It is generally estimated that algae contribute more than 50% of global carbon fixation. They form a major constituent of the soil flora on most agricultural land. They act as important binding agents on the surfaces of these soils as well as adding organic matter and thereby increasing the nitrogen content. In addition several species of blue-green algae (*Cyanobacteria*) are known to be nitrogen fixers both on the soil surface and in rice paddies (Isichei, 1990).

Nigeria is bounded on the coast by the Atlantic Ocean and is blessed with an ample number of freshwater bodies. Most of its landmass of about 924,000 km2 is suitable for agriculture. The utilization of the vast agricultural potential is still substantially primitive without inputs resulting from modern science and technology. To get more out of the land and water resources the spectrum of resources has to be widened to meet the demands of an increasing and more sophisticated population. It is with this in mind that we now discuss the role of algae, a resource hitherto unexplored in agriculture, industry and environmental conservation. In this regard we view algae not as 'lost' crops but as resources in the wild that are yet to be utilized.

ALGAE IN NIGERIA

Not much work has been done on algae in Nigeria. Recently, Lawson and John (1987) published a Flora on the marine algae and coastal environment of tropical West Africa. The publication is reputed to be the most comprehensive report on marine algae in the sub-region. Nwankwo (1990a, b) reported on the diatoms and dinoflagellates, respectively, of the Lagos lagoon. He listed forty-seven diatoms, thirty-three of them, according to him, being reported for the first time thus illustrating the paucity of data on Nigerian marine algae. There have been, however, many more studies of the algal flora of freshwaters (Imevbore and Okpo, 1975; Okusami and Odu, In Press, 1992). On land, Isichei (1980) found *Scytonema myochrous* to be the dominant blue-green alga in surface crust samples collected from thirty locations in forest and savanna zones of Nigeria. He found ten genera, namely *Lyngbya, Mastigocladus, Microcoleus, Nostoc, Oscillatoria, Phormidium, Plectonema, Schizotrix, Scytonema* and *Tolypothrix* to be variously present in the crust samples. Findings from the studies mentioned above show that Nigerian waters and land mass contain the species of algae that have been known to be of use in agriculture and industry. These uses will now be discussed and wherever applicable the potentials for Nigeria will be mentioned.

ROLES OF ALGAE IN AGRICULTURE

Algae play three major roles in agriculture (See Isichei, 1990), namely

i. Physical improvement and protection of soils;

ii. Contribution of nitrogen to agroecosystems; and

iii. Primary biomass production for use as food

(a) **PHYSICAL IMPROVEMENT AND PROTECTION OF SOILS:**

Metting et al. (1988) stated that cryptogamic crusts could be useful in consolidation and stabilization of surface through prevention of soil erosion, improvement of water infiltration and retention and enhancement of seedling establishment. Soil aggregate stabilization by algae is achieved by adsorption and binding of particulates by cell wall polysaccharides as well as enmeshment by living filaments. Metting *et al.* (1988) report that *Chlamydomonas* and *Asterococcus* improve the intergrity of soil aggregates subjected to disruption by wind. Burns and Davies (1986) had earlier observed that *mucilaginous microalgae* are used as soil conditioning agents in some parts of the United States.

Surface crusts or microalgae can also improve water infiltration and retention in soils. Cornet (1981), as cited by Metting et al. 1988) reported that a *Scytonema* crust in Senegal reduced soil moisture loss by almost 18 times compared to soil without crust. Shields and Durrel (1964) observed that algalmats provided a substrate for the germination of seeds of higher plants.

It needs not be over-emphasized that the Sudan savanna and Sahel zones of Nigeria that are subject to intense desertification pressure could be reclaimed using algae. The occurrence of algae is pH dependent with blue-greens performing better than other algae at higher pH. Soils in arid and semi-arid zones are usually high in pH and so would favour the growth of blue-green algae. What needs to be done is to first identify the algal flora in the affected localities or, find out if there are already developed flora/species from similar ecologies. Such flora could then be mass produced, harvested and used in the affected areas. Establishment may be difficult in sandy soils so initial dressings may be necessary. St. Clair *et al.* (1986) have showed that slurries prepared from mature crusts could be used as inocula in a semi-arid rangeland in Utah, U.S.A.

(b) **CONTRIBUTION OF NITROGEN TO AGROECOSYSTEMS:**

All heterocystous and several nonheterocystous and unicellular blue-green algae fix atmospheric nitrogen (see Stewart 1980 for a list of species). It has been shown that the fixed nitrogen is transferred to other organism (Fogg, 1974).

The best known cases of the use of algae in agriculture is algalization the practice of inoculating flooded paddies with mixtures of nitrogen-fixing blue-green algae (Venkatarama,n 1972). Reynaud and Roger (1978) report that fixation in rice paddies in Senegal could range from 10 to 30 kg N ha $^{-i}$ per cultivation cycle.

On land Isichei (1980) observed fixation rates of between 2 - 8 kg N ha $^{-1}$ per year by blue-green algal crusts dominated by *Scytonema* from various ecological zones of Nigeria. Skarpe and Henriksson (1987) observed nitrogenase activity corresponding to 0.6-2 m mole and 6.8 m mole N2 fixed m^{-2} hr^{-1} in crusts containing *Nostoc* and *Scytonema* in the Kalahari desert.

Admittedly, the quantity of nitrogen fixed by algae and added to agroecosystems is small, especially in terrestrial ecosystems but in low input agriculture such small additions might make a difference in yields. We might, however, observe that algalization is an ancient culture that has survived the times and it is expected that it will be beneficiary of improvements brought about by biotechnology and genetic engineering. And Nigeria has immense potential for paddy rice production and therefore algalization.

(c) **PRIMARY BIOMASS PRODUCTION FOR USE AS FOOD:**

In cultures the potential productivity of algae is higher tnan that of tropical forests, marshlands, or intensive agricultural systems (Richmond

1986). Isichei (1990) has observed that the ascendancy of biotechnology and genetic engineering in the last decade has made cultivation of algae a reality. Mass cultured species are listed by DePauw and Persoone (1988) and Regan (1988). The marine species are cultured as direct feed for fish and other aquatic organisms (Lembi and Waaland 1988).

Spirulina platensis, a rich source of protein, is consumed by the kanem people around Lake Chad (Switzer 1980, see also Isichei 1990). This species is found in lakes of very high pH in many parts of tropical Africa. Melack (1979) found that the organisms attained a high photosynthetic rate of 12.90 mg02 m^{-3} h^{-1} in Lake Simbi in Kenya. Reynaud and Roger reported that a flooded dune soil in Senegal attained an average algal biomass of 400 g m-2.. *Chlorella* is mass produced in China and Southeast Asia for sale in Japan as a protein-rich food and Kawaguchi (1990) puts the number of factories producing it as at 1979 at 46. Taiwan is reported to produce 1000 dry tons of the same alga annually (Soong 1980).

Nigeria's aquaculture industry will benefit from mass cultivation of algae both directly for food and as feed for animals and fish.

THE ROLE OF ALGAE IN INDUSTRY

Various kinds of cell wall material extracted from different algae have been found to be of tremendous economic value in the pharmaceutical, food and other industries. Agar, a complex polysaccharide used in bacteriology is extracted from the walls of certain species of red algae, for example *Gelidium, Gracilaria.* Carrageenin, also a cell wall polysaccharide extracted from *Chondrus* and sometimes from *Gigartina* is used as Pharmaceutical emulsifier. The compound is also used in the cosmetics and brewing industries, and in the food industry in making ice cream, whipped cream etc. Alginates which are salts of alginic acid found in the cell wall of brown algae such as *Fucus* and *Laminaria* are used in the manufacture of flame-proof materials and plastic articles. The biochemistry of these and other related compounds have been discussed by Mackie and Preston (1974). Diatomite, from diatoms is used in the manufacture of many industrial filtration devices, is effective as an insulator and used in high temperature furnaces. It is also used as abrasive in polish and toothpaste manufacture. *Dunaliella,* a green alga that tolerates hypersaline environments is now good source of beta-carotene and glycerol (Borowitzka and Borowitzka 1988). *Porphyridium* is a source of mucilages. Several other extracellular and intracellular products of algae have potentials in the chemical and pharmaceutical industry and have been discussed by Hallebust (1974).

ROLE OF ALGAE IN ENVIRONMENTAL CONSERVATION:

Algae are very important in sewage disposal especially in the tropics where open sewage oxidation ponds are used. The presence of algae facilitate oxygenation. This principle is involved in natural purification of streams and natural water bodies that are subject to pollution from sewage and organic matter (See Ekundayo, 1978). The presence or absence or certain algal flora in water bodies gives an indication of the level of pollution of such water bodies.

Oxidation ponds will continue to be used in sewage disposal in Nigeria. The algal flora associated with such ponds should be identified, assessed for efficiency and eventually reared in mass culture. In this way small, efficient oxidation ponds will be established to ensure better sanitation in the rural areas.

CONCLUSION:

The highlights of the roles algae could play (See Table 1) in soil enrichment and conservation, as sources of important organic compounds in the food and health industry and as water purifiers in sewage and stream systems point to their potentials in Nigeria. Such roles rarely get a mention and algology is still at its most rudimentary stage in Nigeria. Most works consist of a compilation of lists of species present in chosen ecosystems. We hope that with challenges posed by an urgent need to industrialize using local raw materials algae will come to mind when we think of natural resources and that they do not continue to remain one or Nigeria's lost and forgotten crops

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Table 1. Microalga and their useful products in agriculture, industry and environment. (After Knutsen and Metting 1990).

Microalga	Products and Uses
Cvabobacteria (blue-green algae)	
Spirulina	Protein, health, foods, - linolenic acid, water soluble dyes.
Anabaena, Nostoc, Aulosira, other genera	biofertilizers
Lyngbya, Oscillatoria, Calothrix	antibiotics, antineoplastic compounds. toxins, phenolics
Phormidium	emulsifier, polysaccharides
Anabaena, Aphanizomenon, Microcystis	anatoxin, saxitoxin
various genera	phycobilins, restriction endonucleases
Chlorophyceae (green algae)	
Chlorella	feed protein, wastewater oxygenation, proline. H_2. health foods. pigments
Dunaliella	carotene, glycerol
Scenedesmus	wastewater oxygenation. feed protein
Botryococcus	hydrocarbons
Chlamydomonas. Asterococcus	soil conditioners.
Neochloris, other genera	triglycerides
Neospongiococcum, other genera	carotenoids
Bacillariophyceae (diatoms)	

Microalga	Products and Uses
Phaeodactylum	wastewater oxygenation, palmitic acid
Chaetoceros, other genera	lipids
Thalassiosira, Navicula,	
Chaetoceros, other genera	aquaculture
Cryptophyceae (cryptophytes)	
Cryptomonas, other genera	carotenoids
Pyrrophyceae (dinoflagellates)	
Gonyaulax, Gymnodinium,	saxitoxin, other toxins,
Crypthecodinium other genera	carotenoids
Euglenophyceae (euglenoids)	
Euglena	tocopherol
Rhodophyceae (red algae)	
Porphyridium	polysaccharides,
	arachidonic acid
Crysophyceae (golden-brown algae)	
Isochrysis, Ochromonas,	lipids, aquaculture,
Prymnesium, other genera	carotenoids
Eustigmatophyceae	
Nannochloris	lipids
Xanthophyceae (yellow-green algae)	
various genera	lipids, aquaculture.