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# Assessment of the Aquatic Macrophytes and Algae of the Fosu Lagoon, Cape Coast. Ghana

**Felix Jerry Akpabey***
Council for Scientific and Industrial Research -Water Research Institute. Environmental Biology and Health Division, P.O. Box AH 38, Achimota, Accra. Ghana

**Ruth Amole**
Council for Scientific and Industrial Research Water Research Institute. Environmental Biology and Health Division, P.O. Box AH 38, Achimota, Accra. Ghana

**Abstract:** The Fosu Lagoon serves as a major ecological, economic and cultural (religious) significance to the inhabitants of the community. It provides livelihoods for local fishermen, as well as habitat for rare flora and fauna, is of key importance to the local climate and provided recreational opportunities for the inhabitants of Cape Coast. In recent years, increased human activities have led to deterioration of both fresh and coastal waters in many regions of the world. The Environmental Protection Agency of Ghana have rated the Fosu Lagoon as one such lagoon and is considered the third most polluted lagoon in Ghana after the Korle and Chemu lagoons. Climate change variability has been associated with declining water resources among other factors. Climate change studies in Ghana have shown that major basins in the country are already experiencing water stress and with increasing environmental deterioration, limited water availability and pollution would have tremendous negative impact on aquatic ecosystems including coastal waters such as lagoons. The study revealed that the Fosu Lagoon is covered with mats of mixed vegetation (with Paspalum vaginatum and Typha domingensis dominating) which grow around the banks and over shallow sections of the Lagoon and parts of the landing sites. The weeds contribute to health problems by providing suitable habitats, refuge and food for vectors of water-borne and water related diseases (snails Biomphalaria sp. and Bulinus sp. for intestinal and urinary schistosomiasis and mosquitoes for malaria). Other macrophytes present include: Pistia stratiotes, Nymphaea sp., Eleocharis, Ipomoea aquatica, and the duckweeds. The death and decay of the plant matter is leading to the rapid silting up of the Lagoon and therefore a reduction in the volume of water to be stored as well as the quality thereby decreasing the oxygen content and inadvertently affecting the fauna through oxygen demand reduction. It is therefore being recommended that stringent control of anthropogenic pressures through integrated catchment management will ensure the restoration of the Fosu Lagoon.

**Keywords:** Lagoon; Anthropogenic; Livelihoods; Climate change; Habitats; Ecological significance; Macrophytes.

## 1. Introduction

About 90 lagoons exist along the coastline of Ghana and some of them particularly the Korle and Fosu lagoons are regarded as polluted because they have become receptacles of waste materials such as heavy metals and poly aromatic hydrocarbons (PAHs). Traditionally, Lagoons in Ghana have important cultural and environmental significance because mangroves associated with these lagoons provide indirect protective effects and also local fishing grounds for surrounding communities. The Fosu lagoon has been added to the list of water bodies with ‘dead zones’ and this is a source of concern to individuals who depend on it for their livelihood, regulatory agencies as well as the Cape Coast Metropolitan Assembly. Activities of people living or working in the immediate vicinity of Fosu lagoon are contributing a lot to the gradual extinction of the lagoon. For instance, through the activities of the mechanical garages, spraying shops, schools and the Metropolitan Hospital, wastes are discharged into the lagoon daily. Such discharges enrich the lagoon sediment with heavy metals and organic manure. In addition to toxic pollutants, increased nutrients, especially nitrogen and phosphorus, from city sewage and fertilizers from agricultural areas have also proven to be very damaging to aquatic ecosystems. High nutrient levels are known to cause harmful algal blooms in both freshwater and marine habitats. In turn, algal blooms impact aquatic biodiversity by affecting water clarity, depleting oxygen levels and crowding out organisms within an ecosystem. In some instances algal blooms have produced neuro-toxins that have led to species die-offs and illnesses such as paralytic shellfish poisoning. Large-scale die-offs of marine species resulting from nutrient over-enrichment and harmful algal blooms can drastically impact marine food webs and ecological dynamics. Excessive phytoplankton growth from raised nutrient levels can also reduce water clarity thereby reducing light transmission available for the growth of submerged aquatic vegetation, which serves as an important habitat for fish, crabs, and other species. Currently a lot of weeds have grown in the lagoon and the surface area has reduced significantly due to siltation.

*Corresponding Author

In aquatic ecosystems, hypoxia refers to a depletion of the concentration of dissolved oxygen in the water column from what can be near 9 mg/L (roughly the maximum solubility of oxygen in estuarine water on an average day), to below 2 mg/L. If hypoxic conditions are reached, these local, atypically low oxygen conditions can profoundly affect the health of an ecosystem and cause physiological stress, and even death, to associated aquatic organisms. While hypoxia can occur naturally, periodically both hypoxia, and the more extreme condition of anoxia (a total loss of dissolved oxygen), may indicate a stressed environment resulting from a systemic problem of an overabundance of nutrients (i.e., eutrophic conditions). Eutrophication is defined as an increase in the rate of supply of organic matter to an ecosystem [1]. An increase in the rate of supply of organic matter is either from external sources or from production within the system through biological processes stimulated by increased nutrients. Increased organic matter and, more specifically, nutrient inputs can lead to a variety of deleterious effects, including overgrowth of aquatic plants like dense nuisance and toxic algal blooms. Aquatic plants rapidly increase in abundance by uptaking these excess nutrients, and through photosynthesis, converting this matter into energy. When these plants die, their organic material sinks to bottom waters and is decomposed by microbes (e.g., bacteria), consuming oxygen in the process, which may lead to hypoxia, and in extreme cases, anoxia [2].

Aquatic macrophytes are a diverse conglomeration of macroscopic vascular vegetation or plants including some relatively "large plants" living either in, on or at the periphery of freshwaters. These aquatic plants include ferns, mosses, macroalgae, angiosperms and flowering plants as well as large trees that require saturated conditions or access to standing freshwater to thrive [3].

Aquatic macrophytes are commonly grouped simply as emergents, free floating, floating-leafed and submerged, depending on the habit of the plant. In this study, the following definitions were used: **Emergent:** These are plants with roots attached to the substratum, with leaves and flowers (if present) protruding from the surface of the water, e.g. *Phragmites, Typha* and *Eleocharis.* **Free floating**: These are plants whose roots are not attached but suspended in the water, with the leaves and flowers borne above the water surface, e.g. *Lemna*, *Salvinia* and *Eichhornia.* **Floating-leafed:** Plants rooted, with their leaves and flowers only spreading on the water surface e.g. *Nymphaea.* **Submerged:** Submerged plants are those that are entirely suspended in the water column with no part appearing above water and not rooted, e.g. *Ceratophyllum,* some *Potamogeton* and *Vallisneria.*

## 2. Phytoplankton (Algae)

Algae (singular *alga*) are a term that encompasses many different groups of living organisms. Algae capture light energy through photosynthesis and convert inorganic substances into simple sugars using the captured energy. Algae range from single-celled organisms to multi-cellular organisms, some with fairly complex differentiated form. Algae have been traditionally regarded as simple plants, and some are closely related to the higher plants. Algae are a very diverse group of organisms that vary widely in size, shape, colour and habit. Ten or so phyla are represented in freshwater. The algae have been grouped by their major features. Some of these are artificial groups (i.e. not necessarily related to their taxonomy) but are convenient ones for the pond dipper.

Algae are usually found in damp places or bodies of water and thus are common in terrestrial as well as aquatic environments. However, terrestrial algae are usually rather inconspicuous and far more common in moist, tropical regions than dry ones, because algae lack vascular tissues and other adaptations to live on land. Phytoplankton primary production is generally the major supply of food for the pelagic food chains of large lakes [4]. Chlorophyll concentration indicates the trophic level of the lake. It is also a measure of the phytoplankton production potential. Though all autotrophic algae contain chlorophyll, the chlorophyll concentration need not be directly correlated with biomass; their relationship is affected, for instance, by illumination, nutrient concentrations and the species composition of the phytoplankton assemblage.

With the energy from sunlight, phytoplankton can assimilate inorganic carbon from water and these results in the formation of organic matter and release of oxygen. What happens in the photosynthesis can be simplified as the following expression:

$6\ CO_2 + 6\ H_20 \text{ - > } C_6H_{12}0_6 + 6\ 0_2$

According to this formula, primary production can be estimated using many techniques. In the simplest case, it can be done by measuring the carbon dioxide uptake or oxygen output due to photosynthesis.

## 3. Objectives

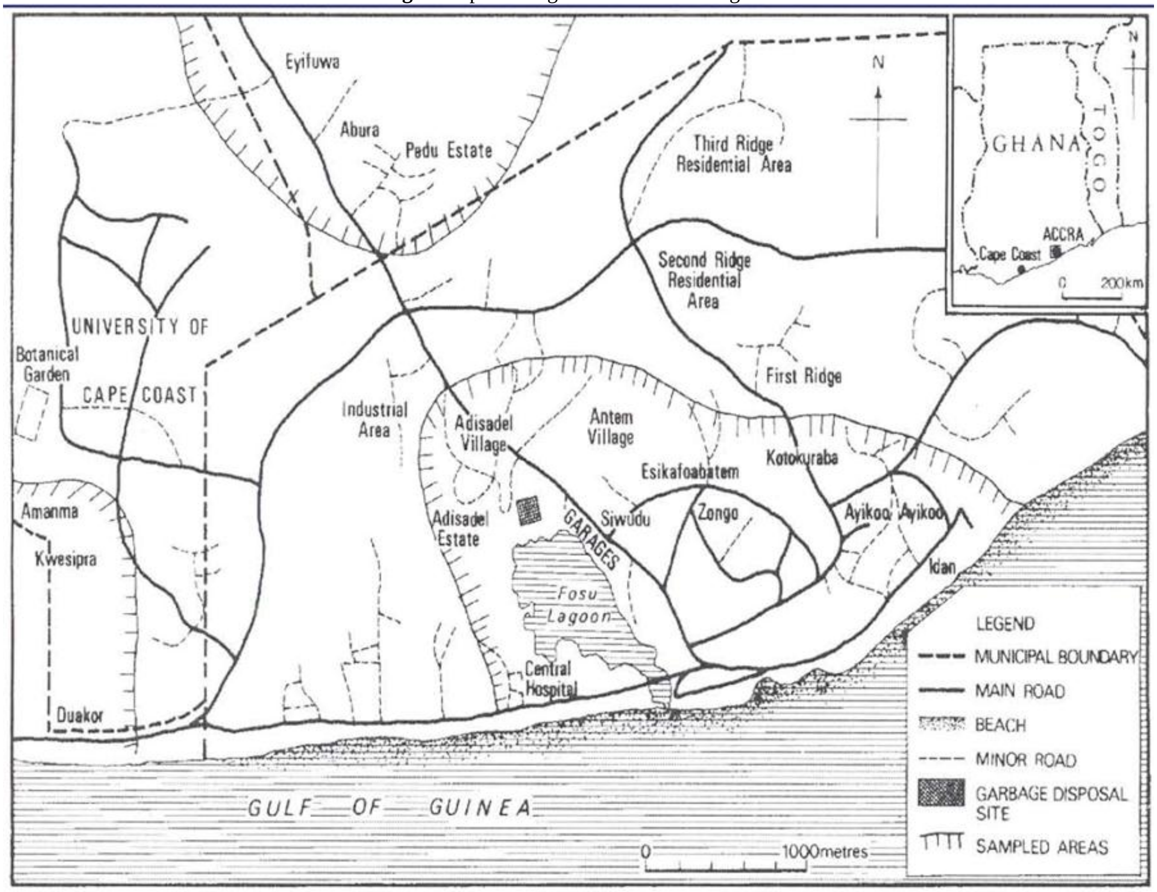
To assess the aquatic macrophyte and algal infestation levels of the Fosu Lagoon,

## 4. Materials and Methods

### 4.1. Study Site

Fosu Lagoon is in the metropolis of Cape Coast, Ghana in West Africa. The lagoon lies (5° 07'N, 1° 16'W), covers an estimated area of 61 ha and has an average water depth of 16 cm and hence considered shallow [5]. The area receives two wet seasons in a year, the major one from April to July and a minor season from September to November. The lagoon is surrounded by many sites that act as point sources for discharge of pollutants. These include domestic waste discharges from a highly polluted area, a metropolis transport garage on the northern side of the lagoon, and an industrial waste discharge from mechanical workshops on the north eastern side. Drains from an educational institution and a nearby hospital, household dumping and sewages characterize the environs of the lagoon. The human activities in the study area is immense and eutrophication has caused massive sedimentation and especially in the more populated northern sector, one can walk many meters on waterweeds as the lagoon has been transformed into waste and marsh land.

**Fig-1.** Map showing location of Fosu Lagoon




*Source*: Survey of Ghana.

## 4.2. Assessment of Aquatic Macrophytes

A reconnaissance survey of the site was conducted from a boat and on foot and the vegetation recorded by notes. These included habit and life form of the plants. Sampling sites were selected and the choice of the sites was based on ease of accessibility to the sampling sites and the extent of coverage of the aquatic macrophytes present in the Fosu Lagoon. The macrophytes were then identified in the field with the help of literature whiles those that were not readily identified were transported in labelled polythene bags to the Ghana Herbarium, located in the Department of Botany of the University of Ghana, where they were identified to species level.

The macrophytes were also sorted into their life forms. Plant samples were obtained by hand cutting 3-quadrat samples from each site during the sampling session and weighed (wet weight) and labeled. This was done in order to be able to determine their wet weight from which the biomass ($g/m^2$) was estimated.

## 4.3. Assessment of Phytoplankton (Algae)

Water samples were collected from the Fosu Lagoon at twelve (12) sites, two from the seaward portion, two from midstream and two from the riverine portion and also from identified point sources of pollution, i.e. from the entry point of effluent from the Nurses and Midwives Training College (NTC), Cape Coast, the mortuary effluent entry point of the Cape Coast Metropolitan Hospital, the St. Augustine's College effluent entry point, the Adisadel Mechanics effluent entry point and rubbish dump, the main storm drain from Siwdu (behind the Robert Mensah Sports Stadium) and from a domestic effluent point near the Metro Mass Transit Bus Terminal and transported to Accra for analysis in the laboratory. All the samples were preserved with Lugol's solution immediately after collection.

In the laboratory, the samples were well shaken and aliquots of 25 ml were transferred into counting chambers for analysis. Identification and enumeration of algae was done using a Carl Zeiss inverted microscope as described by Lund, *et al.* [6]. Sedimentation was carried out in counting chambers with a settling time of 4 hr for every 1cm of water column of the sample [7]. All colonies and filaments were counted as individuals, and the average number of cells determined for 20 individuals and cell concentration calculated. In order not to contaminate the samples, counting chambers were cleaned with detergent after each sample analysis and the cover slides were also changed. Identification was carried out using the manual of algal species from Laboratoire D'Ichtyologie Museum National D'Histoire Naturelle, Paris (1958).

# 5. Results

The study revealed that the Lagoon is covered with mats of mixed vegetation (with *Paspalum vaginatum* and *Typha domingensis* dominating) which grow around the banks and over shallow sections of the Lagoon and parts of the landing sites. The weeds contribute to health problems by providing suitable habitats, refuge and food for vectors of water-borne and water related diseases (snails *Biomphalaria* sp. and *Bulinus* sp. for intestinal and urinary schistosomiasis and mosquitoes for malaria). Other macrophytes present include: *Pistia stratiotes*, *Nymphaea* sp., *Eleocharis*, *Ipomoea aquatica*, and the duckweeds.

## 5.1. Wet Weight Estimation of Aquatic Macrophytes

A 0.25m$^2$ wooden quadrat was randomly placed on weed samples (floating, submerged and emergent) on the water surface. All the plants enclosed in the quadrat were removed, mopped and weighed to determine the wet weight. At each sampling site, three different samples were taken and the mean values calculated (see table 1 below).

**Table-1.** Wet weight of plant samples harvested from the 0.25m$^2$ quadrats at the sampling sites

| Fosu Lagoon | Sample 1 (weight in kg) | Sample 2 (weight in kg) | Sample 3 (weight in kg) | Mean value (weight in kg) | Weight of samples in kg/m$^2$ |
|---|---|---|---|---|---|
| Site 1 | 3.30 | 3.35 | 3.50 | 3.38 | 13.52 |
| Site 2 | 4.20 | 4.50 | 4.85 | 4.52 | 18.08 |
| Site 3 | 3.45 | 3.80 | 3.80 | 3.68 | 14.72 |
| Site 4 | 3.20 | 3.40 | 3.15 | 3.25 | 13.00 |

From the table, the mean weight of the weeds at site 1 per 0.25m$^2$ is 3.38 kg, which is equivalent to 13.52 kg/m$^2$. For site 2, it is 18.08 kg/m$^2$, site 3 is 14.72 kg/m$^2$ and site 4 is 13.00 kg/m$^2$. These weights of the weeds show the level of weed infestation of the Fosu Lagoon. The amounts of fresh weight of plant matter estimated for the Fosu Lagoon pose a great threat to the life of the Lagoon. This is because death and decay of the plant matter will lead to the rapid silting up of the lagoon and therefore a reduction in the volume of water to be stored by the lagoon. The massive presence of plant matter also affects the quality of water since the decaying weeds add taste and odour to the water, decrease the oxygen content and inadvertently affect the fauna through oxygen demand reduction. The weeds also trap polythene bags, food wrappers and other plastic containers along the fringes of the water column and create pollution problems along the lagoon shorelines.

## Algae

**Table 2.** Types of phytoplankton and concentrations in the Fosu Lagoon (Counts/l)

| Taxa | Sampling Sites | | | | | | | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | NTC | Mortuary | Augustines' | A. Garage | Stadium | Riverine 2 | Midstream 1 | Midstream 2 | Seaward 1 | Seaward 2 | |
| **Chlorophyta (Green Algae)** | | | | | | | | | | | |
| *Ankistrodesmus* | - | 500 | - | - | 440 | 600 | - | - | - | 640 | 545 |
| *Chlamydomonas* | - | - | - | 10400 | - | 100000 | 20600 | - | - | 2520 | 33380 |
| *Chlorella* | 1500 | - | - | 520 | - | - | - | - | - | - | 1010 |
| *Micrasterias* | - | - | - | - | - | - | - | - | 600 | - | 600 |
| *Mugeotia* | - | 5800 | - | - | - | - | - | - | - | - | 5800 |
| *Pediastrum* | 2900 | 3800 | - | - | 720 | - | - | - | - | - | 2473.3 |
| *Scenedesmus* | 5800 | 8900 | 1760 | 2240 | 3520 | 38400 | 12400 | - | 8800 | 4200 | 9557.7 |
| *Staurastrum* | 500 | - | 200 | - | 240 | - | 200 | - | - | - | 285 |
| *Synura* | 500 | 1700 | - | 280 | - | - | - | - | 1200 | 760 | 888 |
| *Ulothrix* | - | - | - | - | 640 | 800 | - | 2080 | 4200 | - | 1930 |
| *Volvox* | - | - | - | - | 240 | - | - | - | - | - | 240 |
| **Cyanophyta (Blue-green)** | | | | | | | | | | | |
| *Anabaena* | 5900 | - | 1040 | 640 | 720 | - | 5600 | 640 | 1200 | - | 2248.6 |
| *Aphanocapsa* | - | - | 2640 | - | 1000 | - | - | - | - | - | 1820 |
| *Lyngbya* | - | - | - | - | 360 | - | - | - | - | - | 360 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Merismopedia* | 8900 | 20100 | 3560 | 4680 | 1920 | - | - | 4240 | 6600 | 5000 | 6875 |
| *Microcystis* | - | - | 4206 | - | - | - | - | 5920 | - | - | 5063 |
| *Oscillatoria* | 500 | - | 960 | - | 240 | 900 | 4200 | 720 | 900 | - | 1202.5 |
| *Planktothrix* | 6500 | - | 520 | 360 | 1560 | - | 8500 | 1400 | 1400 | 1440 | 2710 |
| *Psedanabaena* | - | - | - | - | 1840 | - | 6600 | - | 2900 | 1400 | 3195 |
| **Bacillariophyta (Diatoms)** | | | | | | | | | | | |
| *Achnanthes* | - | 800 | - | - | - | - | - | - | - | - | 800 |
| *Amphipleura* | 1600 | 600 | - | - | - | - | - | - | - | - | 1100 |
| *Navicula* | - | - | 200 | 80 | 240 | 300 | - | 360 | 900 | 240 | 331.4 |
| *Synedra* | - | 500 | - | - | - | - | - | - | 800 | - | 650 |

## 6. Discussions

During the study of the Fosu Lagoon, a total of 23 algal taxa were encountered. These include 11 Green algae (Chlorophyta), 47.83%; 8 Blue-Green algae (Cyanophyta) 34.78% and 4 Diatoms (Bacillariophyta) 17.39 %. Thus, abundance of Green algae is greater than Blue-Green algae which in turn are greater than the Diatoms. The algal distribution in the lagoon appears to be uneven as some sampling points appear to be richer in the algal composition and density as against others. For example, the discharge points of some of the drains leading into the lagoon appeared to be richer in the algae than the main water column i.e. the drain from the NTC had 10 algal species, Mortuary had 9, St. Augustines' College had 9, the main drain from behind the Stadium had 14 and the storm drain entering the Lagoon at the seaward end had 11 as against 7 from the midstream and 6 from the riverine portions. The dominance of the Green and Blue-green algae in the lagoon is what gives it the dark greenish appearance. Excessive growth of algae in the water will lead to eutrophication.

Eutrophication generally promotes excessive plant growth and decay, favouring simple algae and plankton over other more complicated plants, and causes a severe reduction in water quality. When algae die they sink to the bottom where they are decomposed and the nutrients contained in organic matter are converted into inorganic form by bacteria. The decomposition process uses oxygen and deprives the deeper waters of oxygen which can kill fish and other organisms. Enhanced growth of aquatic vegetation or phytoplankton and algal blooms disrupts normal functioning of the ecosystem, causing a variety of problems such as a lack of oxygen needed for fish and shellfish to survive. The water becomes cloudy, typically coloured a shade of green, yellow, brown, or red.

### 7. Conclusions

The amounts of fresh weight of plant matter estimated for the Fosu Lagoon pose a great threat to the life of the Lagoon. The death and decay of the plant matter is leading to the rapid silting up of the Lagoon and therefore a reduction in the volume of water to be stored. The massive presence of plant matter also affects the quality of water from the reservoir since the decaying weeds add taste and odour to the water, decrease the oxygen content and inadvertently affect the fauna through oxygen demand reduction. Eutrophication also decreases the value of rivers, lakes, and estuaries for recreation, fishing, hunting, and aesthetic enjoyment. Health problems can occur where eutrophic conditions interfere with drinking water treatment [8].

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