Outlining the causes and effects of Algae bloom at Ghana's West Coast

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Abstract

The first incidence of algal bloom within Ghana's west coast was recorded in 1993, however many years down the line, the growth is still persistent in her territorial waters. A lasting solution is yet to be found. This has therefore led to several social, economic and environmental problems in the affected regions. The study outlined the possible causes and effects of algal bloom within Ghana's West Coast. The perception of the local people with regards to the causes was also investigated.

The method used was by direct observation and use of questionnaires following a case study approach in the Half Asini District. This was to address the pertinent question of what the people think is the cause of the bloom.

The study found that the growth of Algae was alarming, with a newer breed having a much negative consequence on the economic livelihood of the people and environment. It was also found that current studies on the issue were minimal— with less than necessary attention being given by stakeholder. However, scientific investigations were underway, though a preliminary report suggested it is a migration of Sargasso Sea species. Recommendations included the need for consented government efforts to investigate, device a control measure to curtail its spread, and continuous public education as a control measure was recommended as well.

1. Introduction

Ghana's West Coast forming part of the coastline of West Africa covers the south-western part of Ghana; shares boundary with La Cote d'Ivoire to the West, and the East, running along the trajectory of the Greenwich meridian line passing through part of Ashanti and Brong Ahafo regions bound North, the Tema port city, and the Gulf of Guinea down South as shown in Figure 1 below (courtesy: Worldatlas.com, 2019).

It has an area of 23,760sq km, a coastline of 192km; consisting mostly of sandy beaches (some safe for swimming and surfing) and lines of coconut-palm, merging seamlessly with mangrove vegetation, high evergreen forest reserves and diverse wildlife at various sections. This makes the area economically viable. The local folks engage in fishing activities as their main occupation and source of income.

As of the year 2019, the population of the western region is projected to be 3million approximately from the 2010 population census and subsequently, have been divided into north and south. The region, nona.net (n.d) indicated mainly comprising four distinct districts namely the Sefwi Wiawso district (Wiaso & Akontombra), Nzema-East district (Axim & Ellembelle), Wassa-West district (Tarkwa Nsuayem & Prestea H. Valley) and Shama Ahanta-East district (Sekondi Takoradi & Shama).

This beauty of the coast in recent times, however, according to the Environmental Protection Agency (EPA) and National Disaster Management Organization (NADMO) has deteriorated resulting from the alien species, algae bloom — and as such, threatening the livelihood of local fisherfolks in the region (Napo A. F. and Korku Devitor, 2010). In addition, it's destroying the recreational and tourism industry as the cost of maintaining the area to make it fit for purpose keeps rising. Helplessly, it has become a dumping site for refuse and human excreta instead of a community effort at gathering bloom concentration at the shore. This is the sea along the coast, does threaten marine life if left unchecked. Although there is no officially recognised threshold level on data in Ghana, algae can be considered to be blooming at concentrations of hundreds to thousands of cells per millilitre, depending on the causative species. The large is mainly with the increase nonpoint source pollution being the primary cause of harmful algal blooms, toxic contamination, and among others problems that plague coastal waters. This nonpoint is spearheaded by weather and oceanographic conditions (U.S. Commission on Ocean Policy, 2004).

Effectively, *the outbreak of this greenish substance in Ghana's territorial waters and her inability at finding a lasting solution to addressing the problem is causing a lot of problems to the coastal people living in the affected areas in terms of their occupation (i.e., the rapid loss of jobs and source of income through low activities of fishing-related businesses and recreational beaches of the tourism industry). This subsequently also has significant effects on the marine life within the affected waters: hence, NADMO* declared the situation in 2010 "a national disaster with government forming a task force to investigate the cause and make recommendations as to how the problem must be dealt with"- thus, an October 12, 2010 news report by The Lead, cited by Ghanaweb.com.

The study, therefore, seeks to outline the possible causes of algal bloom within the affected regions and to highlight its social, economic and environmental effects with the hope that a solution may be found to the problem in earnest. This would be achieved by finding out the possible causes of algal bloom; highlighting what some of the social, economic and environmental impacts of the species bring to the country of invasion; examine the government's role in managing the problem; investigate the coping mechanisms of dwellers in the affected areas; conclude by providing suggested solutions or recommendations to resolving the problem in the west coast of Ghana. The research upon completion is expected to: serve as background material for the National Disaster Management Organization (NADMO) and the Ghana Environmental Protection Agency (EPA) while suggesting solutions to controlling the algal bloom invasion, and help restore fishing activities to the affected regions while creating awareness of the dangers that are associated with the algal bloom species. The study will focus mainly on the Jomoro district as a case study due to its closeness to the Ghana-Cote d'Ivoire boundary, where the accumulation of the algal bloom is very intense. The study will make use of the qualitative and quantitative data gathered by sampling. This will be interpreted alongside observational field data in the final analysis purposed at providing an effective outcome representative of the entire west coast region of Ghana.

2. Review

Ghana is a signatory to the 1982 United Nation's Convention on The Law of the Sea (UNCLOS 82) and marks its Territorial waters 12NM out like any other coastal nation from the baseline along the coast. This is the region of the first-ever findings of algae bloom conducted by the Environmental Protection Agency (EPA) in 1995, though not conclusive as to the real cause, they were of the view that toxic waste chemicals dammed into the sea in Cote d'Ivoire one way or the other are the origin of the bloom (EPA, 1995; Myjoyonline.com, 2014). The problem has since been under monitoring.

2.1 Growth and Conditions of Growth of the Algae Species

Algae are an important life form in the ocean. Life in the ocean is maintained in balance by forces of nature and by predator-prey relationships unless some external pressures upset the balance. When a balance upset leads to conditions more favourable for the reproduction and growth of algae, an explosive increase in the number of algae cell density occurs. Such rapid increases in the algae population are called 'algal blooms'. The most widely publicized type of algal bloom species is that associated with the production of toxin (chemical substance) harmful to animals that feed on them (and hence is known as a harmful algal bloom or HAB), and/or algae bloom that cause a tint in the water because of the photosynthetic pigments they contain. The latter commonly is known as a "red tide," and may or may not be harmful. They nonetheless affect life in the ocean and on land in both positive and negative manner (Castro and Huber, 1997; Wells, M. L., et al, 2015). Bulent S., et al, (2013) also indicated that "in very high densities (algal blooms), these algae may discolour the water and outcompete, poison, or asphyxiate other life forms."

Algae are typically one of the few types of phytoplankton species that grow in freshwater as well as marine bodies. Algae need light and food in order to thrive and grow. Hence, Castro and Huber (1997); Wells, M. L., et al, (2015), lists air temperature, humidity, sunlight, and nutrients (food) as their growth factor to grow and reproduce. Its habitation is mostly within 60 to 90 meters (200 to 300 feet) of ocean water surface forming the epipelagic zone –rich in oxygen, easily penetrated by sunlight and warmer than water at lower levels. Some algae such as Naviculapennata have been recorded to a depth of 360 m (thus according to Bulent S., et al, 2013).

2.2 Types of Algae

On the basis of their habitat, algae can be categorized as aquatic (planktonic, benthic, marine, freshwater, lentic, lotic), terrestrial, aerial (subaerial), lithophytic, halophytic (or *euryhaline*), psammon, thermophilic, cryophilic, epibiont (epiphytic, epizoic), endosymbiont (endophytic, endozoic), parasitic, calcifilic or lichenic (phycobiont) (Bulent S., et al, 2013).

Although there are over 20,000 known varieties of algae, algae can be classified into two (2) main categories namely harmful or toxic algal blooms (HABs) and non-harmful or non-toxic algal blooms. These blooms occur due to an imbalance in the environment which causes algae to bloom in large numbers owing to the abundance of nutrients. However, they are not toxic and therefore pose no direct harm to aquatic or marine life as well as humans. However, the harmful/toxic algae blooms (HABs) is only 2% of all the 5000+ species of marine phytoplankton that exist worldwide. Blooms of harmful algae can have large and varied impacts on marine ecosystems, depending on the species involved, the environment where they are found, and the mechanism by which they exert negative effects. Due to their negative economic and health impacts, HABs are often carefully monitored. The “Red tide” is a term often used to describe HABs in marine coastal areas, as the dinoflagellate species involved in HABs are often red or brown, and tint the seawater to a reddish colour. The more correct and preferred term in use is harmful algal bloom, because: these blooms are not associated with tides, but causes reddish discolouration of water and are harmful.

2.3 Causes of HABs’ Migration

It is unclear what causes HABs; their occurrence in some locations appears to be entirely natural (Doucette and Kirkpatrick, 2003). While in others they appear to be a result of human activities. Furthermore, many different species of algae can form HABs, each with different environmental requirements for optimal growth. The frequency and severity of HABs in some parts of the world have been linked to increased nutrient loading from human activities. According to Bulent et al, (2013) “Algae can be used as indicator organisms to monitor pollution in various aquatic systems. In many cases, algal metabolism is sensitive to various pollutants. Due to this, the species composition of algal populations may shift in the presence of chemical pollutants.”

In other areas, HABs are a predictable seasonal occurrence resulting from coastal upwelling, a natural result of the movement of certain ocean currents. The growth of marine phytoplankton (both non-toxic and toxic) is generally limited by the availability of nitrates and phosphates, which can be abundant in coastal upwelling zones as well as in agricultural run-off. The type of nitrates and phosphates available in the system is also a factor since phytoplankton can grow at different rates depending on the relative abundance of these substances (e.g. ammonia, urea, nitrate ion). A variety of other nutrient sources can also play an important role in affecting algal bloom formation, including iron, silica or carbon.

Coastal water pollution produced by humans and systematic increase in seawater temperature has also been suggested as possible contributing factors in HABs. Other factors such as iron-rich dust influx from large desert areas such as the Sahara are thought to play a role in causing HABs. Some algal blooms on the Pacific coast have also been linked to natural occurrences of large-scale climatic oscillations such as El Niño events. While HABs in the Gulf of Mexico have been occurring since the time of early explorers such as Cabeza de Vaca, it is unclear what initiates these blooms and how large a role anthropogenic and natural factors play in their development. It is also unclear whether the apparent increase in frequency and severity of HABs in various parts of the world is a real increase or is due to increased observation effort and advances in species identification technology.

2.4 Possible Causes of the Increase in HABs

The frequency, duration, and intensity of algal blooms are related to many biological, chemical, and physical factors, although, many of these complex relationships have not yet been identified. Four possible reasons have been advanced for the increased frequency and expanding geographic occurrence of HABs. First are improved methods of detection and greater monitoring efforts. These increase the probability that a HAB species will be recorded. Second is the introduction of exotic species via ballast water exchange or aquaculture practices (Hallegraeff, 1993; Damak, 2017). A third possibility is that blooms result when grazers fail to control the algae species' growth (Smayda, T. J., 1997). Fourth, blooms may result from climate changes, as well as human activities, such as increased pollution and nutrient inputs, habitat degradation including dredging, resource harvesting, and the regulation of water flows (reference). All of these reasons are possible explanations for increasing HABs, and one or any combination of them may apply to a particular species.

2.5 Effects of Algal Bloom

Algal blooms provide large concentrations of algae that produce organic compounds needed by higher organisms, ranging from oysters, clams, and mussels to human beings. For this reason, productivity increases in areas where algal blooms occur. More algae in the water mean that more carbon dioxide is used from the atmosphere and that more oxygen is released into the atmosphere. Oxygen is necessary for many living things, including humans. The production of dimethyl sulphide gas helps protect algae from harmful ultraviolet rays so they remain healthy and thus can continue the cycle of sustaining life on Earth. Even in the coldest parts of the ocean, algae provide the primary source of organic material to animals at the bottom of the food chain. Organic materials are moved up the food chain as higher organisms feed on those lower down the chain. For example, algae have been found in Antarctic sea ice. As seawater freezes, algae living in the water are frozen in the ice, where they later can be released during a thaw. These algae are a vital source of food for krill, the shrimp-like organisms eaten by penguins, seals, seabirds, and whales. However, the negative effects or disadvantages of algal blooms will be considered under the following classifications:

a. Human Health and Environmental Effects of Harmful Algal Blooms: The detrimental effects range from cell and tissue damage to organism mortality, and can be caused by several mechanisms, thus toxin production, predation, particle irritation, induced starvation, and localized anoxic conditions. As a result, their impact is on living organisms of the coastal ecosystem, from zooplankton, fish larvae to humans.
b. The Social and Economic impacts of Algal Bloom: can lead to disruption of recreational use of the waterway – impeding modes of transport and beaches thereby posing serious threats to tourism. This is buttress by Turgeon et al.'s (1998); US Commission on Ocean Policy (2004) assertion that expansion of harmful algal blooms over 25

years along the US coast was responsible for economic losses amounting to US$100 million per each year by the United State federal government. To this effect, Murkute and Chavan (2018) in their finding observed that the mass of fish kill studied occurred in the Lendra Pond with a heavy load of algal blooms, of which its decaying resulted in the depletion of Dissolved Oxygen and subsequently the release of toxins. Again, a single outbreak of paralytic shellfish poisoning in the North-eastern United States was estimated to cost six million US dollars (the US $6 million) (Shumway, 1988; Bulent, et al, (2013)). Even the non-toxic harmful algal bloom can also have devastating effects on a natural bio-diverse community (LaPointe, 1997; Littler, 2006). Such sea-grass beds are important nursery habitat for pink shrimp, spiny lobster, and finfish.

2.6 Management of Algal Bloom

Notable Occurrences: a red tide in 1972 was caused in New England by a toxic dinoflagellate Alexandrium. February 2002, also saw massive die-off and decay of algae from a nearshore HAB, causing a rapid reduction in dissolved oxygen concentration, driving tens of thousands of rock lobsters to "walk out of the sea" near the Elands Bay in South Africa's West Cape province.

Control Measures: the most direct way of control algal blooms is to reduce the availability of nutrients. Water management organizations across the world are actively pursuing a variety of nutrient control strategies. However, for some aquatic ecosystems nutrient control, is impractical, ineffective or is simply too costly. In other cases, chemical or biological treatments are helpful alternatives when administered properly.

(i) Chemical Treatment: involves the administering of chemicals (algaecides include sodium carbonate proxyhydrate products, Green Clean™ and Pak 27™, etc.) to affected water bodies. Some have proven to be effective while others have posed a danger to marine life. Therefore, each chemical has its restrictions and toxicity to animals. Before using these chemicals, it is expected that the manufacturer’s directions are adhered to carefully hence a consulting professional advice is crucial.

(ii) Biological Treatment: is the use of various carp fish species to control submerged and floating algae. Grass carp (*Ctenopharyngodon Idella*) is mainly used for aquatic weeds and attached submerged algae, such as Nitella sp. and Chara sp. Where they do not prefer filamentous algae to eat, grass carp will eat Lyngbya. The silver carp (Hypophthalmichthys molitrix) is an effective treatment for controlling filamentous algae, including blue-green algae. However, both species are non-native species and have several regulatory restrictions to employing them as a means of weed control. When they are allowed, they are restricted to triploid carp. Triploid carp has an extra set of chromosomes that render the fish sterile, therefore prohibiting a population explosion if the fish escapes into an uncontrolled area. These fishes are an economical choice and thus have proven their effectiveness in controlling the growth and spread of algae. However, there is a mixed outcome (e.g. grass carp tend to consume non-nuisance vegetation— leaving the noxious algae as the second choice) when using carp for blooms control. It is not clear why preferences change between lakes over time.

(iii) Physical Treatments in ponds include aeration and airlifts. While aeration does not kill or remove algae from the water, it oxygenates and stirs the water column, creating the conditional shift from toxic and smelly blue-green algae to preferred green algae species. The resultant algal population is usually not dense or toxic to other organisms within the ponds.

(iv) Mechanical Treatments: Harvesters are sometimes used to skim dense mats of blue-green lyngbya algae from the surface of lakes and rivers. Lyngbya normally grows in dense mats at the bottoms of nutrient-enriched lakes and spring-fed systems. These mats produce gasses during photosynthesis that often cause the mats to rise to the surface. At the surface, the winds pile the algal mats against shorelines or in navigation channels. These mats can be several acres in size. Managers have developed a process called "grubbing" whereby harvesting machines lift the mats off submerged plants such as native eelgrass, without cutting the eelgrass. By removing the blanket of lyngbya from the eelgrass, the plants grow and expand.

(v) Alternative Control Measures: Phosphorus inactivation products (aluminium sulphate, sodium aluminates, and calcium hydroxide/carbon dioxide) generally limits the growth of freshwater algae in most lakes. A direct relationship exists between the amount of phosphorus in a lake and the quantum of algae bloom site growing in the lake. As phosphorus levels increase, the amount of algae increases too. Long-term management of algae requires the removal of phosphorus sources to the water body. External sources of phosphorus are storm-water runoff, septic system effluents, fertilizers, pet wastes, waterfowl, agriculture, and even rainfall. Removing or modifying the phosphorus sources as possible is even not enough. Phosphorus-enriched sediments can simply release phosphorus into the water through a process known as ***‘internal loading***.’ In this situation, lake managers can use nutrient inactivation techniques to remove the phosphorus from the water column (called precipitation) and to retard its release from the sediments (called inactivation). Lake managers introduce either aluminium, iron, or calcium salts for phosphorus inactivation of lake sediments. However, Aluminium sulphate (alum) is the most commonly used nutrient inactivation chemical for lake projects. When applied, alum forms a fluffy aluminium hydroxide precipitate called a floc. As the floc settles, it removes phosphorus and particulates (including algae) from the water column (precipitation). The floc settles on the sediment where it forms a layer that acts as a barrier to phosphorus. As sediments release phosphorus, it combines with the alum and is not released into the water to fuel algal blooms (inactivation). Nutrient inactivation is only appropriate where internal loading is a significant phosphorus source. For appropriate nutrient inactivation projects, the length of treatment effectiveness varies with the amount of alum applied and the depth of the lake. Thus, for the shallow lake, the amount of alum required for phosphorous inactivation per a lake’s depth if applied adequately should last for a period of eight to ten years or more respectively (E. B. Welch, and G. D. Cooke, 1999).

3. Methodology

This section describes how the study was conducted— giving a vivid description of the process from the population sampling through the actual data collection process. Description of type of study and study design employed as well as the area of study is well laid out. Also embedded in the sample size of the population used, the sampling procedure and the selection method applied. Finally, it outlines the data management and analysis procedure, and limitations of the study.

3.1 Research Design

The study carried out was based on interviews with a well-structured questionnaire and purely community-based. This design was deemed appropriate since it allowed the researcher to have a one-on-one correspondence with the small group enabling the full contribution of respondents while purposely gathering specific information.

3.2 The Study Area

The Study Area chosen for the research (seen in Fig 2) is the district lying between Latitudes 04^0 55” – 05^0 15˝ N and Longitudes 002^0 15˝ – 002^0 45˝ W and is bordered on the North by Wassa Amenfi West and Aowin Suaman districts, Nzema East Municipal on the East, La Cote d'Ivoire is to the West and the Gulf of Guinea to the South. The size of the district is 1344sq. km and the district capital is Half-Assini. The Jomoro District, created by Legislative Instrument 1394 in 1988 is located in the Southwestern corner of the Western Region (nona.net, n. d).

The focal point of the research, therefore, is on Half Assini (shown in Figure 2 and 3) —the town with the worse experience of algal bloom infestation due to the closer proximity to the Ghana-Cote d'Ivoire boundary.

It is bounded on the South by Latitude 040 80” N and the Atlantic Ocean {Gulf of Guinea} and in the North by Latitude 050 21” N and the Nini River. It also within Longitude 0020 35” W and 003 07” W.

3.3 The Target Population, Sampling and Data Gathering

The population of the study was the local people in the community. A variety of sampling methods were applied in this study over the first quarter of 2011. Purposive sampling and simple random sampling were applied in sampling the informants from the community. In the end, a total of 40 people were selected and an appropriate age criterion was designed to address the issue of biases. The data collection methods that were used during the study were interviews with a structured questionnaire and direct observation. Interview guides (structured questionnaire) were used to interview informants in the community. Lastly, there was a review of secondary data from printed and published material relating to the study. Researchers were also opportune to interview experts from the EPA, a local government council member and a non-governmental stakeholder.

3.4 Data Analysis

Data presentation and analysis was done using frequency tables and graphical presentation of quantitative data of the responses from the respondents. This was further corroborated with field visits and observations –helping draw contextualized interpretations and conclusions on qualitative data obtained with incisive discussions.

4. Findings And Discussions

This section of the study deals with the presentation, analysis and discussion of the various findings obtained during the study and thus, involves the analysis and interpretation of all data collected from the fieldwork. The parameters in this section comprise Background characteristics of respondents; Knowledge and perceptions of the respondents; and Management control measures. The economic, social and environmental implications were the studies main parameters towards the findings.

4.1 Background characteristics of the Respondents

The background parameters examined the age of respondents (Ref. to Table 1), the frequency of their responses (Ref. to Fig 4), together with their level of education (Ref. to Fig 5), and their occupations (Ref. to Fig 6).

Table 1: Background of respondents

Age of Respondent	Frequency of response	Percentage (%) of respondents
18-22	0	0
23-27	2	5
28-32	4	10
33-37	3	7.5
38-42	7	17.5
43-47	4	10
48-52	15	37.5
Above 52	5	12.5
Total	40	100

The study of the 40 respondents, indicated that their background in terms of occupation, experiences, knowledge and perception related closely to the economic & environmental development in the area of study.

Halve (representing 50 per cent) of respondents interviewed were within the age group of 43 and 52 years which reflects the current demography of the coastal communities (see Fig 4). The second large group of respondents are within the age group of 33 and 42years.

Respondent mostly were elementary school levers representing 75 per cent of the total population interview (see Fig 5). Only 5 per cent had education up to senior high school level. This unique background of the respondent informs the nature of occupation and career choices they living in the community make.

Respondents engaged in fishing made up 83 per cent of the responding population, with only 2 per cent in public service. 10 per cent are involved in trading and 5 per cent in farming (see Fig 6).

4.2 Knowledge and perception of Respondents

The participants were asked about their awareness of; (i) cotton factories in the neighbouring town across the western border of Ghana, (Half Assini), and (ii) the impact of waste dumping from these factories on the marine environment over the years. They were also asked about the use of, (iii) social-environmental facilities such as toilet and the (iv) awareness of algae bloom and its (v) economic effect on their lives. The results are shown in Figures 7 to 8 respectively.

4.2.1 Respondents' knowledge of nearer factories:

The results in Fig 7 and 8 indicate that the participants were aware of the existence of the cotton factories and the fact that they were dumping waster into the sea along the Ghana-Cote d'Ivoire boundary. However, upon further probing none of the 38 who claimed they are aware had witnessed this incidence but all 38 respondents based their answer on assumptions because of the cotton-like nature of the algae when it dries up.

4.2.2 Awareness of Social Facilities in communities of the Area

On the issue of social facilities, most of the respondents were aware of toilet facilities provided for the various communities in the area, however, concerning its usage, the response is shown in Figure 9. Inadequate toilet facilities in communities tend to leave the majority of the population defecating along the coastline close to the sea in Ghana.

Upon interaction with one of the assembly members for the community, Mr John Ekobor, he revealed that a total of four (4) Kumasi designed Ventilated Improved Pits (KVIPs) each with a capacity of 12 seats have been installed for the community with a population approximating 10,000-15,000. This points to inadequacy and thus explains why the majority of the people defecate along the coast, which eventually ends up in the sea.

The largest population of the respondents rarely use the toilet facilities. Further probing revealed that this largest group of respondents often resort to defecating along the coast and into the sea as an alternative means of convenience. This is also a rich source of nutrient provided for planktons in the area over a long period.

4.2.3 Awareness of Algae Bloom and impact on their occupation and Fish Consumption

The respondents’ response on the effects of algal bloom on their machinery and equipment, the response is indicated in Figure 10. The small group of respondent who did not experience the effect comprised traders, farmers and civil servants. However, regarding challenges with eating sea fish from the area due to the problem, the responses are indicated in Figure 11 below. Thirty-five (35) respondents representing the majority experienced issues from eating fish from the sea in the area. Further probing revealed, a change in the taste of the sea fish was a huge concern but no health complications and therefore had no recorded health complications. The small group of respondent who did not experience the effect comprised traders, farmers and civil servants. However, regarding challenges with eating sea fish from the area due to the problem, the responses are indicated in Figure 11.

4.2.4 Awareness of any New Breed of Algae Bloom

Concerning their awareness of the new breed of algae at the coast, the majority response was to the affirmative (seen in Figure 12).

Fig 13 is a picture of this new breed observed on the coast.

When asked about the possible reason for the new breed, they responded, it could easily be deduced that the negative attitudes of the locals towards pollution in the sea by their excreta (urea, ammonia), could likely introduce nutrients that facilitated the growth of the bloom.

4.3 Management and Control

The respondents were asked about their awareness of actions taken by the government to manage and control the issue of the algal bloom. A majority (see Figure 14) were aware of government actions. Further probing revealed some of these actions that were taken by the government and when asked if these actions were enough, all thirty-four (34) respondents said no and that much more is needed to be done by the government to tackle the problem of algal bloom that is affecting their community.

They were however vague in their response as to what the various interventions could be.

5. Conclusion

It must be noted, however, that the responses did vary from question to question due to the multiplicity and inapplicability of those questions to some of the selected respondents. Citing myjoyonline news report (2014) which indicated that, *“between January and April 2012, beach seine fishermen in the west were forced to suspend fishing when the weed densities became too high. Coastal Tourism industry was not spared either, and as carried by the Daily Graphic of 23rd April 2014 “Aquatic weeds take over Cape Coast beaches” preventing revellers who normally climax their Easter festivities with beach activities from swimming in the sea”*— the trend observed was consistent with findings of the study.

They further referred to EPA’s preliminary investigation findings. To reiterate, thus according to the then Executive Director of the EPA, the recurrence of the influx in Ghana did not appear to reflect local growth of the weed. He added that EPA’s inquiry with counterparts in Sierra Leone, Liberia and Cote D’Ivoire confirmed influx of the weed in their waters as well. His assertion was consented to by Biological oceanographers who also were of the view the influx originated from the Sargasso Sea and is being carried by the general ocean circulation to locations bounding the Atlantic Ocean, although studies are not yet conclusive. They believe that it is likely to be a reflection of changes in the general ocean circulation in a way that brings more eddy currents closer to shore. This implies that though this current study was able to identify defecation (human excreta) along the coast that ends up in the ocean as one of the possible causes of the algal bloom in Ghana’s West coast, the general ocean circulation could be contributing. The respondents indicated that defecating along the coast was more convenient as the KVIPs were far away from their homes.

Their action did not solely and directly amount to the exponential growth in the local algae bloom of the area. However, the suggestion by EPA’s then Marine Expert, Mr Carl Fiati, that “a set of natural and manmade factors” including indiscriminate and improper domestic waste disposal probably cumulated to trigger phenomenon rightly buttressed our findings.” Again, the sighting of KVIP facilities farther away from the community is to protect the KVIP building from the effect of the sea breeze. Consequentially, this is so because the sea breeze blowing landward reacts with building materials used in the construction of the KVIP facility. Materials such as aluminium roofing, louvre blade, among others, tend to rust. The majority of the population are engaged in fishing as an occupation because it is a coastal community.

Due to the negative impacts of the algal bloom on their fishing machinery and equipment, most of them are out of jobs. However, those of them who still engage in the fishing activities, have their nets constantly entangled with the algal growth. As a result, their fishing nets become overburdened and get torn under the excess stress. Again, the outboard propellers on their fishing boats do also get entangled in the algal growth –preventing them from working effectively and eventually break down. This increases the financial cost of maintenance and repairs of the machinery. Ecologically, the presence of the algal bloom has caused a lot of the fishes to migrate outward into the open sea away from the coast. Thus, forcing the fishermen to go farther out at sea to make a good catch. This has exposed them to much harsher weather conditions and greater life-threatening risks. Imperatively, the farther they do go in search of good catch means the more premixed fuel consumption by their outboard motors. This is affecting them economically and leaving them poorer since the little income earned is spent on fuel. Relatively, the condition today has foster the illegal harvesting of marine mammals (see Fig 15) in place of empty catch.

The harvesting of dolphins and toothed whales as bycatches have seen an increase in the last couple of years, thus according to marine scientist (Ofori-Danson P.K., Van Waerebeek K., Debrah, J. (2003); Ofori-Danson, P.K., Debrah, J., Van Waerebeek, K. (2019)). WildSeas NGO group’s representative Eric, whose works have been to monitor the coast of Axim, and helping release stranded mammals and reptile such as turtle, claim to be a constant witness to the beaching of dead whales and fishing bycatches. According to him, on most of the occasion, he had had to pay fisherfolks from personal funds for the cost (sometimes over GHC1,000) of the dolphin so that they may be released. He, therefore, requested help in this regards as the issue is constantly on the high.

Concerning management, the EPA obtained specimens of the algal bloom for testing and has determined that the Algae were not harmful. However, since they obtained that prove, they haven't done much in terms of its control and management biologically or mechanically. They have employed the services of ZOIL Ghana Ltd.'s Eco-Brigade to physically clean the affected areas within the community. Nonetheless, due to the overwhelming nature of the specimen and low motivation, the personnel from ZOIL Ghana Ltd have not been able to clean the affected areas and have abandoned the work. Biologically, a new breed of algal bloom was noticed in addition to the former the community had been long struggling with. Upon interaction with the assemblyman for the community in the person of Mr John Ekobor, who doubles as the representative of EPA, this new breed of alga started to show up on the coast approximately four (4) months, after the first offshore oil production began in the country (i.e. in March 2011). Figure 16 below shows the old breed.

The EPA on the preliminary conclusion identified the specimen as a Sargassum menace, and scientific investigations were underway. Hence, managing it could be either by a do-nothing approach (to allow it to die naturally) or harvesting and turning them into fertilizer compost for crops. Either way, the community clean-up engagement will be needed. Others suggest locals employ a method of gathering, digging and burying the algae in large pits along the coast.

In a related matter, the recent mass strandings within the months of March 2021 (the GAURDIAN, 2021), widely reported in the media, of the west and east coast of Ghana (mainly, in Axim and Osu Labadi) also raised several concerns of HAB one more time as a plausible cause. Along the coast of Axim was the stranding of over 100s of melon-headed whales, while Osu-Labadi recorded a swamp variety of dead fishes. Efforts were underway to ascertain the immediate cause included an investigation into possible poisoning of the species at sea (The GUARDIAN, 2021). Some scientist suggested the melon-headed whales might have consumed fishes that might have fed on poisonous algae along the food chain. This was highly speculative but worth investigating. Therefore, the growing problem of Algae bloom has a direct impact on the ecosystem of marine wildlife as well as humans and can no longer be taken lightly if coastal and ocean management is to be at the centre of economic and environmental affairs.

5.2 Recommendations

With these findings, recommendations are outlined here, as an attempt to improve the lives of individuals within the affected community and to help find a lasting solution to the algal bloom influx.

5.2.1 Recommendations to Government;

- Further research is needed to confirm the link between human excreta (defecation) into the sea and the blooming of the Algae species.
- Further research is needed to determine a link between the ongoing Oil production offshore and the new breed of algal bloom.
- In the meantime, the sanitation problem within the community must be addressed. It is obvious the toilet facilities provided for the community are not enough in terms of the population ratio or evenly distributed and thus, a reason majority resort to open defecation.

- Regular and intense public education should be carried out within the community to educate members about the health implications of defecating into the sea and along the coast. The traditional leaders should be engaged on all matters.
- The government should consider some of the management and control measures that are discussed in earlier literature reviewed, and adopt the most suitable measures to tackle the algal bloom. Also, the services of more competent organizations should be sought to deal with the management and control of the algal bloom.
- Alternative jobs such as farming and other vocational jobs can be introduced to the local people since the majority of them are fishermen.
- The government should organize a specialized team to probe into the claims of cotton factories dumping their waste products into the sea along the Ghana-Cote d'Ivoire boundary.
- Government should require the Ghana Navy to intensify their patrol along the Ghana-Cote d'Ivoire boundary to check the claims that some factories in Cote d'Ivoire dump their waste materials into the sea.

Declarations

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Conflict of interest: Authors do note here that their judgement may or may not have been impaired by their affiliations with the study. However, on behalf of all authors, the corresponding author wishes to state that at no stage did the study receive any financial support in that regard.

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Conflicts of Interest/ Competing interests

There is no interest other than to see the maritime industry flourishing

Availability of data and material

Interviewed responses are available; however, confidential material cannot be disclosed at this time due to ethical concerns

Code availability

Not applicable

Authors’ contributions

Not applicable

Ethical consideration

No direct sampling of animals affected was carried out at any point in time.

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Figures

Figure 1

Gulf of Guinea, Courtesy, : Worldatlas.com, 2019

Figure 2

Map showing Half Assini along the Gulf of Guinea.

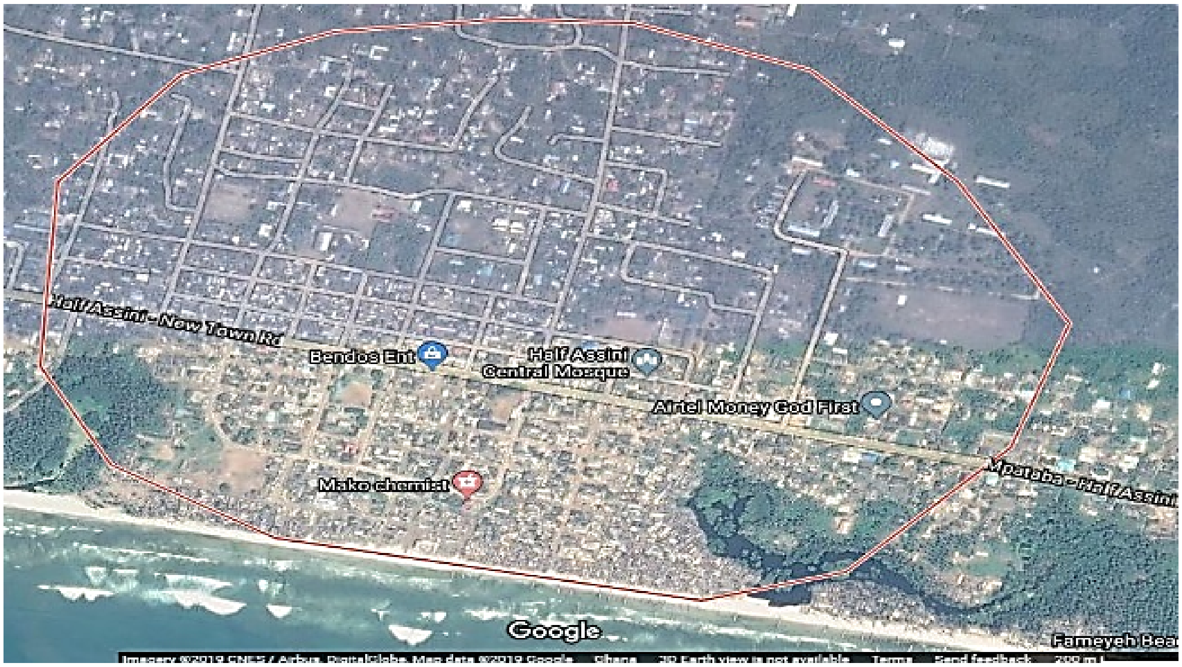

Figure 3

Google Satellite (2019) image of Half Assini along the south western coast in Ghana

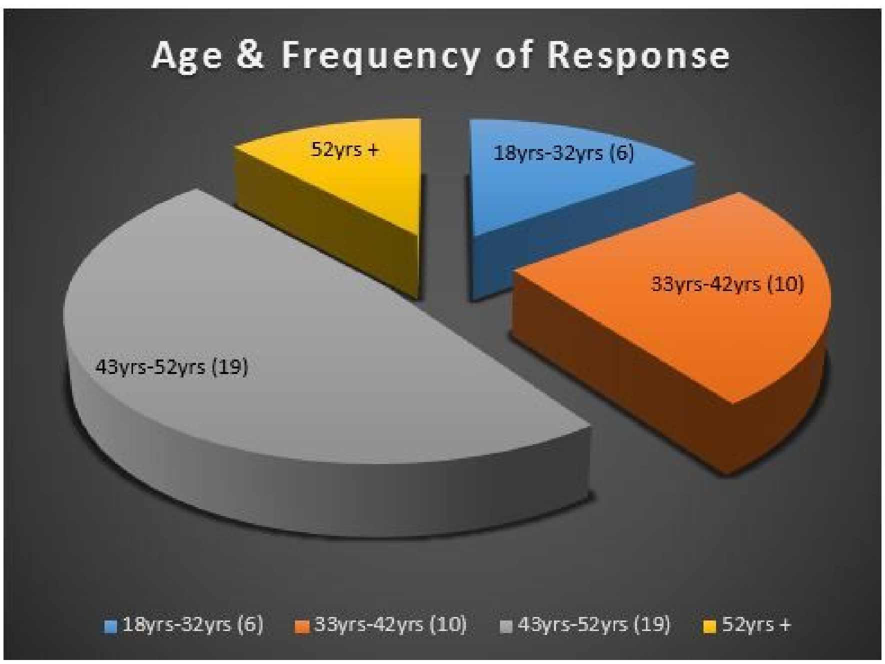

Figure 4

Age of respondent and Frequency of their Response

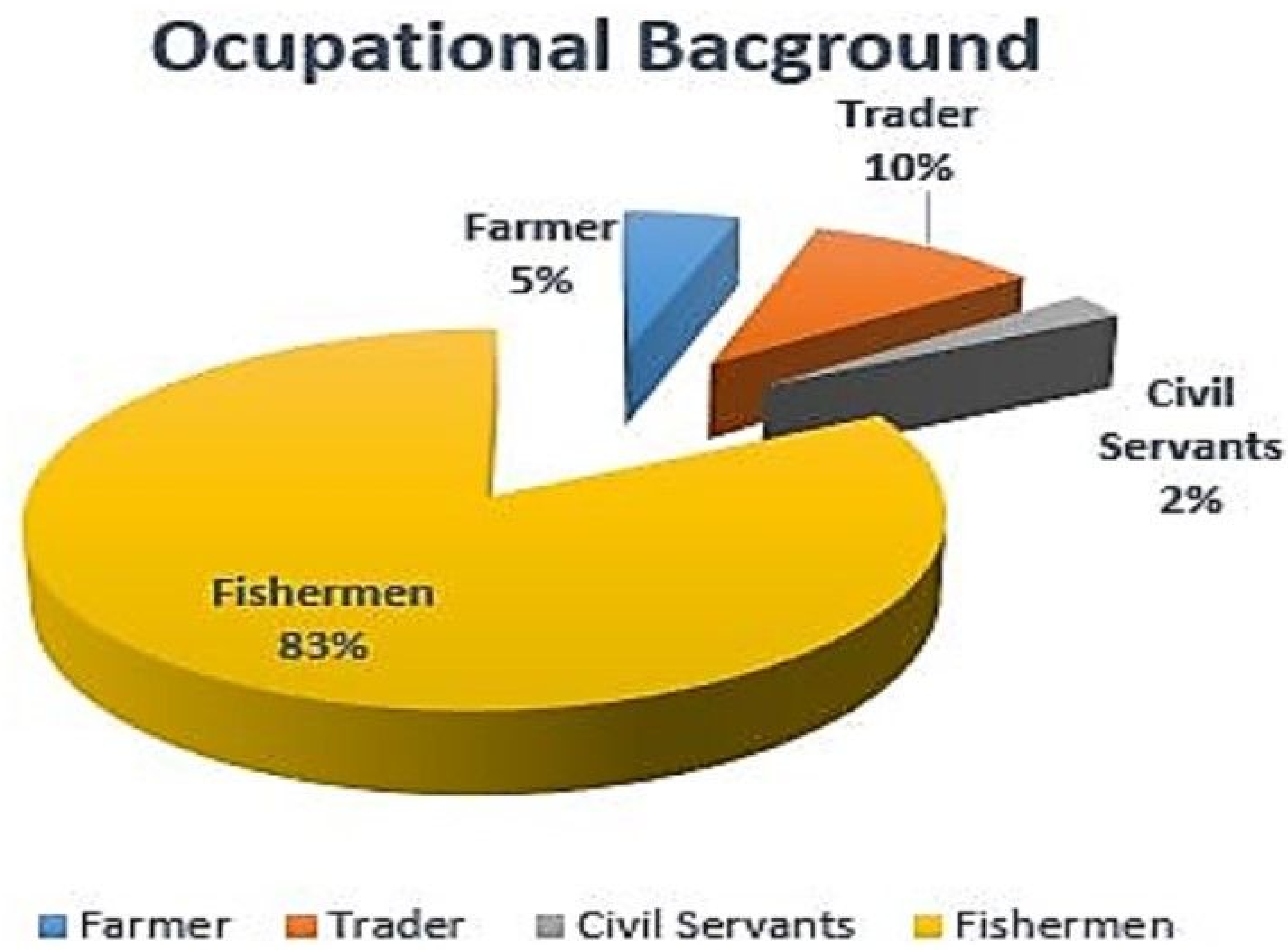

Figure 5

Occupation of respondents

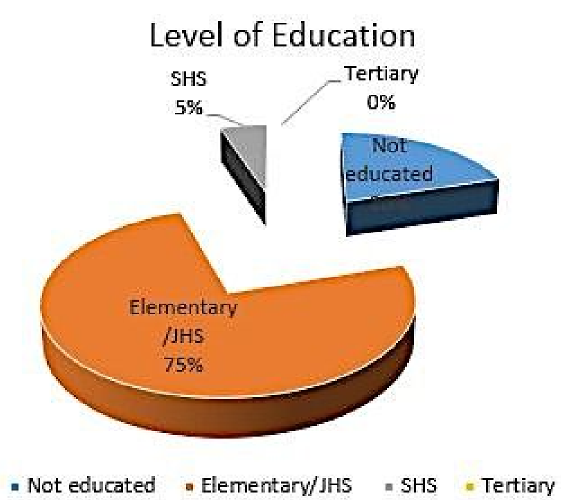

Figure 6

Level of Education of respondents

Figure 7

Awareness of cotton factory

Figure 8

: Awareness of waste dumping by factory

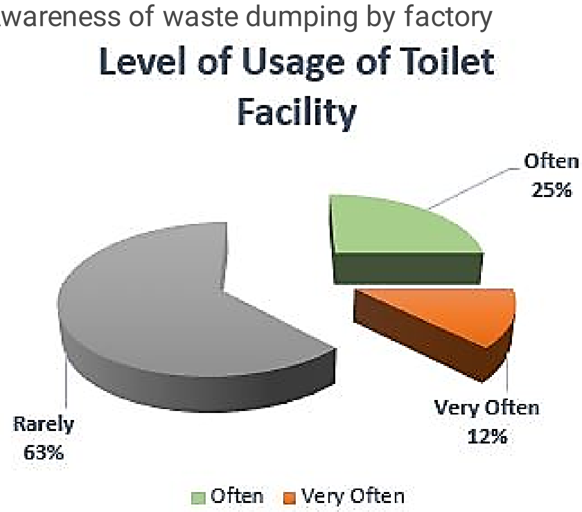

Figure 9

Level of Usage of toilet Facility

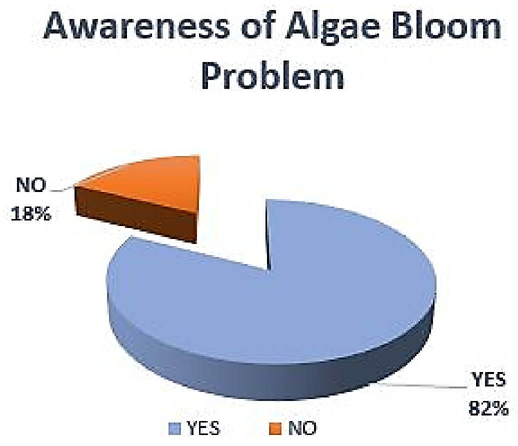

Figure 10

Level of awareness of Algae bloom

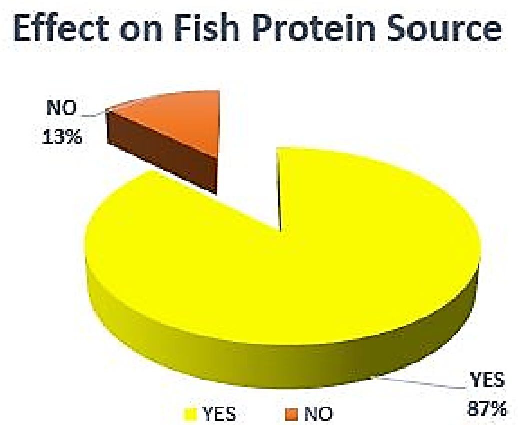

Figure 11

Impact on Food Source

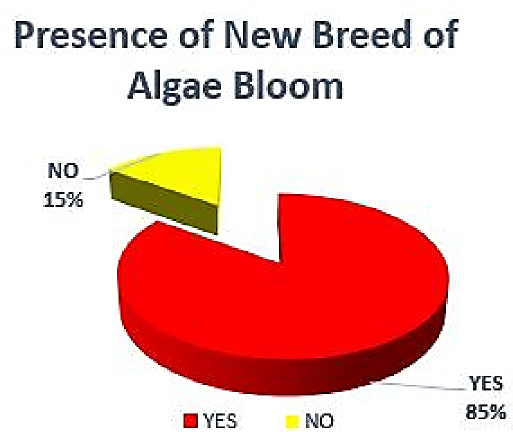

Figure 12

Awareness of the new breed of Algae Bloom

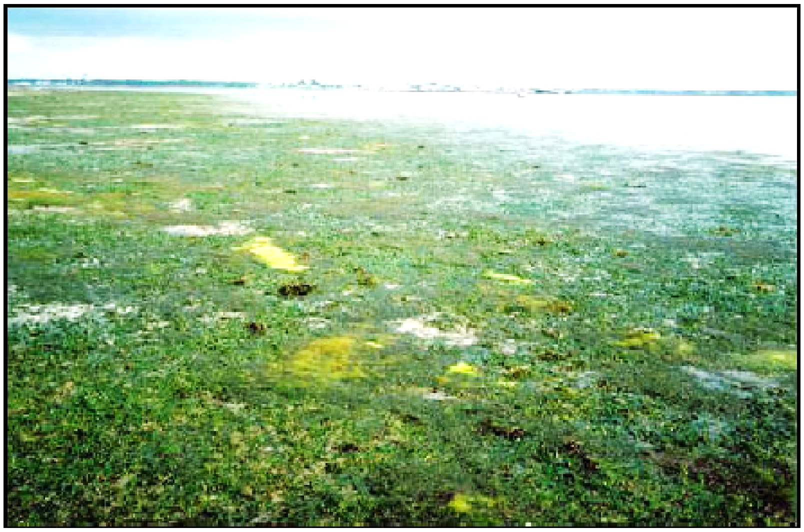

Figure 13

Image of Algae bloom on the coast taken 2014

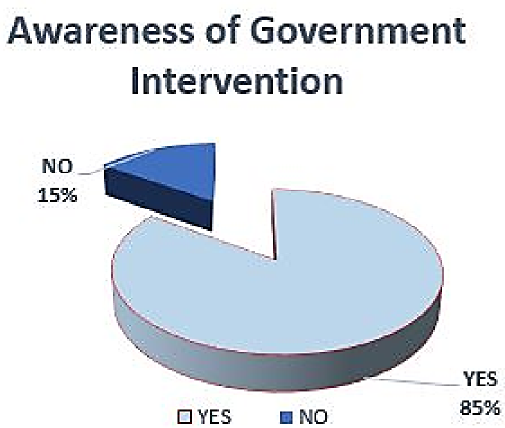

Figure 14

Awareness of Government Intervention

Figure 15

Bycatch Observed of a Mellon-Headed Whale at Axim west. Courtesy Eric of WildSeas (20 April 2021)

Figure 16

Image of Old Algae bloom on the coast

Supplementary Files

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- ALGAECHECKLIST.pdf