AN ASSESSMENT OF DREDGING AS A TOOL FOR MANAGING THE EFFECTS OF SANDBAR DEVELOPMENT AT THE VOLTA ESTUARY

BY

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DECLARATION

I hereby declare that except for references to other researcher's whose works have been duly cited, this is the results of my own research work. Besides, this research work has not been presented elsewhere for another degree or otherwise.

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DEDICATION

I dedicate this work to the glory of Jehovah God for his mercies.

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ABSTRACT

The construction of dams on the Volta River and the consequent regulation of the river's flow pattern led to the development of a permanent sandbar at the Volta estuary that resulted in many problems for the estuary, with the major one being the disruption of salt water in-flow. Poor salinity conditions of the estuary resulted in, among other things, the development of freshwater plants which served as breeding grounds for some planorbid snails which harboured the parasites that cause schistosomiasis. Among the many efforts to solve the problem is the initiation of the ongoing dredging exercise at the estuary which started in 1990. The dredging project has been ongoing for more than twenty years now, but there exist little or no document for reference purposes. The purpose of this research therefore, is to assess the extent to which the exercise has succeeded in solving the problems. It sought to describe the dredging process since this is one of its kind in the country, examine the current trends in saline water intrusion, determine the density of snail vectors of the bilharzia disease as well as assess the impacts of the dredging exercise on the socio-economic lives of people resident on islands at the estuary. These objectives were met through the conduction of in-depth interviews and field observations, the analysis of salinity data from 2001 to 2013, the sampling of snail intermediate hosts of bilharzia at the estuary, as well as the administration of questionnaires to seek the perceptions of residents with regards to the dredging exercise. The results revealed that, dredging began in 1990 with the use of a cutter suction dredger. Dredging is done cutting through the sandbar every six years to create an opening for interactions between water from the river and sea. Silted channels are also dredged to enhance the free flow of water through them. The dredged materials are put to beneficial uses such as the nourishment of river banks. Trends in saline water intrusion, showed an improvement in the extent of sea water intrusion at the estuary. Sea water now travels to areas that are 14 km away from the

sea at high tides. However, average salinity at certain points of the estuary seems to exhibit a downward trend over the years. Although the physical, chemical and biological parameters of the water at all the sites were within the ranges necessary for the proliferation of schistosome snails, no snail was found at the estuary. That could be attributed to the intrusion of saline water up the river during high tides. From the perceptions of the residents of island communities, the dredging exercise seems not to have any positive effect on their economic activities. The areas where dredging seems to be making positive impacts are tourism and health. It is recommended that, members of the communities are engaged in discussions to help take decisions that will benefit them as far as the dredging exercise is concerned. Additionally, the local people especially those resident on the islands should be introduced to other means of making income to help them maintain a good standard of living. With regards to the intrusion of saline water, it is recommended that, further studies be conducted to identify the causes of declining salinity records at certain points in the estuary.

CHAPTER ONE

INTRODUCTION

1.1. Background of the study

Estuaries are valuable resources the world over. They are among the most productive natural environments and among the most sought-after places for human habitation (Roland and Kathleen, 2006). They support major industries, shipping; and tourism. They sustain many organisms, serve as migration routes, and are havens for threatened and endangered species (Roland and Kathleen, 2006). They create much more organic matter than forests, grasslands, or agricultural lands. They also support unique communities of plants and animals especially adapted for life at the margin of the sea.

Many different habitat types are found in and around estuaries, including shallow open waters, freshwater and salt marshes, swamps, sandy beaches, mud and sand flats, rocky shores, oyster reefs, mangrove forests, river deltas, tidal pools, and sea grasses (Good, 1997).

Unfortunately, many of the world's estuaries are troubled. Many estuaries today are being converted into other uses due to increasing population growth and the increasing demand for land for farming, residence and other purposes. This has led to heavy pollution of estuaries and the consequent decline of native fisheries and invasion by non-native nuisance species. In addition to the problems posed to our estuaries as a result of human activities are other problems resulting from natural processes such as the development of sandbars.

Sandbars are common features at the mouths of rivers. They are usually formed under the combined effects of waves, tidal movements, long-shore and cross-shore currents and river flow (Tanaka et al., 2005). As a river flows into the sea, its velocity of flow reduces causing it to deposit the sediments it has transported at the mouth of the river. Such sediments increase with continuous deposition resulting in the formation of sandbars. Even though sandbars occur through natural processes, their formation can be enhanced by alterations in the flow regimes of rivers through human activities such as the construction of dams.

According to Aird (2001), increasing world population has brought about an increase in the demand for water and energy supply. Due to this, governments have dammed over half of the world's rivers for hydroelectric purposes, irrigation, flood control, water storage, and a variety of other uses.

In as much as dams are very important for the welfare and economic development of all nations, their construction come with numerous social and environmental impacts. These impacts, according to World Commission of Dams (WCD), are the "unnecessary prices paid to secure those benefits" (WCD, 2000). Some of the negative impacts of dam construction relevant to this study is the fact that they change the pattern of flow of rivers, reduce their overall volume and change their seasonal variations. Such alterations in a river's flow regime can speed up the deposition of sediments on the river bed and at its mouth to speed up the formation of large permanent sandbars.

Sandbars at river mouths have several influences on the features of a river. They hinder navigation, increase flooding as well as obstruct the intrusion of saline water from the sea into rivers. Such obstruction of saline water intrusion also comes along with its attendant consequences. Some of which include the invasion and proliferation of non-native plant and animal species and the disappearance of native species. The disappearance of native plant and animal species affect the lives of local residents enormously since most of them depend on such species for their livelihood. Invasion and proliferation of non-native species sometimes brings about serious negative effects such as the outbreak of diseases, hindrances to transportation, pollution of water among others to local residents (WCD, 2000). To solve these problems most governments resort to dredging through the sandbars to restore the intrusion of saline water and consequently reduce the negative effects on the people.

Dredging through such sandbars involves the excavation, that is loosening or dislodging, removal and transport of material or sediments from the bottom of the river and the placement of such sediments at an appropriate place. It is usually found in two types; new work dredging and maintenance dredging. New work dredging has to do with the excavation and removal of virgin sediments to deepen channels, as maintenance dredging involves sediment removal from a previously dredged channel to keep it deep**.**

Even though dredging also have some negative effects on the estuarine environment, it has been used all over the world to restore estuaries and improve on the wellbeing of local residents (Cohen, 2005a). Ghana has undertaken minor dredging activities over the years, including the dredging of the heavily polluted Korle- lagoon. The on-going dredging activity at the Volta River Estuary however, can be considered as the most serious dredging activity in the history of Ghana. Its purpose is to clear the almost permanent sandbar at the mouth of the river to enhance saline water intrusion and consequently reduce or terminate the problems it has posed to local residents.

1.2. Problem Statement

The Volta River estuary is the largest estuary in Ghana. Just like all other estuaries, it provides cultural, economic and recreational benefits to many people especially the communities living around it. It is well known for *Galatea paradoxa,* a bivalve mollusc which constitutes an important and affordable source of protein to the riparian human communities of the Lower Volta and has for centuries supported the livelihood of over 2000 people (Adjei-Boateng et al., 2009). The banks of the Volta estuary provide fertile land for farming activities; they serve as major transport routes for most of the surrounding communities and also provide good environments for recreational activities.

The construction of the Akosombo and Kpong Dams on the Volta River in 1964 and 1981 respectively, for the generation of hydro-electricity however brought about negative environmental consequences to the estuary. According to Gordon (2006), the construction of the two dams created ecological changes in the Volta Basin, manifested in the forms of the proliferation of aquatic weeds and increase in snail vectors of Schistosomiasis.

Pople and Rogoyska (1969), also noted that, the construction of the Akosombo Dam changed the regime of the part of the river below the dam, distorting the dry and wet season flow rates. In addition the velocity of flow of the river was reduced leading to a higher level of sedimentation on the river beds.

The low river discharge coupled with high coastal sediment transport resulted in the formation of a sandbar across the estuary which virtually closed it (Gordon and Amatekpor, 1999). This prevented the intrusion of seawater upstream during high tides. As of 1969, it was revealed that, the dry season position of the salt/fresh water boundary had moved 20 to 25 kilometers towards the sea (Pople and Rogoyska, 1969). This situation led to a number of unfavourable conditions at the estuary and to the surrounding communities. Some of these include:

- Flooding of vast inhabited areas on the river banks in times of water spillage by the Volta River Authority.
- The growth of aquatic weeds which disturbed the ecological system leading to the impairment of fishing activities especially the shrimps and clams industries.
- The growth of vector snails that harbour bilharzia parasites which increased the incidence of bilharzia infections in surrounding communities.
- A hindrance to river transport.
- Reduced tourism in the area.

To remedy these problems dredging operations began cutting through the sand bar at the estuary and through channels to decrease the flow resistance for the restoration of salt water in-flow. The Volta River Authority believed the dredge operations will:

- interconnect deeper ponds which will allow salt water to penetrate the whole tidal area
- serve as a protection for communities inhabiting the lower banks from flooding in case of a future emergency spilling of the lakes.
- cover aquatic weeds growing on the banks of the communities for the elimination of the bilharzia intermediate host snails.
- enhance the restoration of fishing and shipping activities in the area.
- boost the tourism industry.

It has been over twenty years since dredge operations began in the Lower Volta Basin and there is inadequate literature on the extent to which the problems mentioned above have been solved. This study therefore aims at assessing the extent to which such unfavourable conditions have been reduced, as well as identify other positive and negative effects that the dredging activity has on the environment and the surrounding communities.

1.3. Objectives of the Study

The main goal of this study is to assess the extent to which dredging has improved saline water intrusion into the Volta estuary and its implications on the density of vector snails that harbour the bilharzia parasite and the livelihood of people living in communities that surround the Volta River estuary.

To achieve this goal, the following specific objectives will be considered:

- Describe the on-going dredging process at Ada.
- Examine the current trends in saline water intrusion into the Volta estuary.
- Determine the prevalence of snail vectors of Schistosomiasis in the estuary.
- Assess the extent to which dredging has affected the livelihoods of the people (fishing, farming, transport, tourism etc.)

1.4. Research Questions

The following research questions will be answered by the study:

1. How is the dredging being done, that is the dredging process, machines being used and frequency of dredging?

2. What are the current trends in saline water intrusion, that is how far is saline water able to travel up the river currently at the surface and bottom, does it show any particular trend, can there be predictions for the future?
3. What is the current state of snail vector density at the estuary? Are there still some snail vectors in the estuary, where are they located, what quantity is available and under what conditions are they found?
4. How has dredging affected the socio-economic activities of island communities?

1.5. Significance of the Study

Rivers and their estuaries provide a lot of benefits to humans. Taking advantage of these benefits most at times results in a lot of negative impacts which may lead to the destruction of these ecosystems if not tackled.

In the case of the Volta River estuary, the construction of the Akosombo and Kpong dams have undoubtedly, brought a lot of benefits to the people of Ghana , but it has also brought about a lot of changes in the ecosystem which consequently affect the people who depend on it. Dredging is one of the efforts being made to address these problems. However, progress made so far has not been documented hence, the need for this project.

A study of this nature is very important because:

- It will help to document the extent to which dredging has helped to solve the environmental problems that arose from the damming of the Volta River and provide recommendations for the future.

- It will highlight the current issues in the intrusion of saline water and its effects. This will help the Volta River Authority in planning the dredging activities in future.
- It will provide information that will form the basis of future research.
- It will raise further questions that may call for further research in the area.

CHAPTER TWO

LITERATURE REVIEW

2.1. Estuaries

2.1.1. Definition of Estuaries

Estuaries according to most of the documents reviewed are transitional zones that are made of a wide variety of environments. They are loosely classified as the zone where fresh water from rivers and salt water from the sea meet and mix. Estuarine environments are complex blends of continuously changing habitats (Good, 1997; Roland and Kathleen, 2006; The Ohio State University, 1997).

Most authors agree that, the complex nature of estuarine environments makes it difficult to come up with a definition for the word “estuary”. The following definition by Donald Pritchard however seems to be widely accepted and cited by most writers; “An estuary is a semi-enclosed coastal body of water which has free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage” (Pritchard, 1967 cited in Good, 1997; Roland and Kathleen, 2006).

The definition given by Pritchard (1967) points out the important features of an estuary and is therefore acceptable.

2.1.2. Importance of Estuaries

The fact that estuaries are very valuable resources is a generally accepted fact. Most authors describe them as being among the most productive ecosystems in the world (Good, 1997; Roland and Kathleen, 2006; The Ohio State University, 1997). Such a conclusion may be due to the many functions they perform. A review of relevant documents has revealed numerous benefits derived from estuaries. Some of these benefits have been discussed in the following paragraphs.

Estuaries serve as suitable places for human habitation. They were the first areas of human settlement and are among the most sought-after places for human habitation (Good, 1997; Roland and Kathleen, 2006).

Fisheries and other commercial activities thrive on the wealth of natural resources provided by estuaries. Many species of fish rely on the sheltered waters of estuaries as places to spawn, this has given estuaries the nickname “nurseries of the sea” (untitled document). Hundreds of marine organisms, including most commercially valuable fish species such as salmon, herring, flounder, crabs, oysters, clams among others, depend on estuaries at some point during their development (Good, 1997; Roland and Kathleen, 2006; The Ohio State University, 1997).

Estuaries also support shipping activities. Protected estuarine waters support important public infrastructure, serving as harbors and ports vital for shipping, transportation, and industry (Good, 1997; Roland and Kathleen, 2006).

Among the cultural benefits of estuaries are recreation and aesthetic value. Because of their quiet waters and nearness to lakes or oceans, estuaries are often attractive places for marinas, home sites, and tourist developments. Recreational activities undertaken in estuaries include, boating, fishing, swimming, surfing, bird watching etc. (Good, 1997; Roland and Kathleen, 2006; The Ohio State University, 1997).

Estuaries are critical for the survival of many organisms as they sustain many species, serve as migratory routes for them and serve as havens when threatened and endangered. They provide ideal conditions for migratory birds to rest in the course of their movements. Many birds, mammals, fish, and other wildlife depend on estuarine environments as places to live, feed, and reproduce. (Good, 1997; Roland and Kathleen, 2006; The Ohio State University, 1997).

The wetlands that surround estuaries also perform very important services. They filter sediments, nutrients, and other pollutants from water draining from upland areas. This process of filtration results in water that is cleaner and clearer for the benefit of both humans and other organisms that depend on it.

Plants and soils in wetlands also serve as natural buffers between the land and sea; they absorb floodwaters and dissipate storm surges. This protects upland organisms as well as valuable real estate from being destroyed by storm and flood. Plants such as salt marsh grasses, mangrove trees, and others prevent erosion and make shorelines stable (Good, 1997; Roland and Kathleen, 2006; The Ohio State University, 1997).

Estuaries also support education. As transition zones between land and ocean, they serve as invaluable laboratories for scientists and students, providing important lessons in biology, geology, chemistry, physics, history, social issues among others (Roland and Kathleen., 2006).

Estuaries are therefore very valuable resources. They are irreplaceable natural resources that must be managed carefully for the mutual benefit of all who enjoy and depend on them. In situations where they get altered as a result of natural occurrences or human activities, efforts must be made to restore them.

2.1.3. Salinity of Estuaries

Estuaries are made of a mixture of freshwater and saltwater. Salinity, the measure of the amount of salts dissolved in water is seen as an important property of estuaries. They are found in proportions that vary according to the location in the estuary.

Unlike fresh water from rivers which has a salinity of 0.5 ppt or less, estuaries usually exhibit a gradual change in salinity throughout their length according to Roland and Kathleen (2006). Salinity levels in estuaries may be oligohaline (0.5-5.0 ppt), mesohaline (5.0-18.0 ppt), or polyhaline (18.0-30.0 ppt). (Lowe-McConnell, 1987; Roland and Kathleen, 2006). It may also be more than 30.0 ppt (same as that of the ocean) near the connection with the open sea, that is known as euhaline (Mitsch and Gosselink, 1986 cited in Roland and Kathleen, 2006).

Salinity also varies based on water depth unless there is high turbulences leading to a well-mixed estuarine column. Salinity, as well as water temperature, is a primary factor in determining the stratification of an estuary. When freshwater from a river meets salt water from the sea, the two do not readily mix especially when there is low turbulence. Fresh water which is warm and less dense usually overlies the seawater pushing in from the ocean which is cold and denser (Roland and Kathleen, 2006). The water at the bottom of the estuary is therefore usually more saline than the one on the surface.

Salinity is a very essential property of an estuary because it plays several roles in ensuring that the estuary performs its functions. Salinity levels determine to a large extent the types of plants and animals that can survive in an estuary. At the upper reaches of estuaries where there is very low level of salinity are freshwater species (freshwater marshes), in the middle portions are species that survive in intermediate levels of salinity (brackish marshes) whilst marine species (salt marshes) inhabit the estuarine mouth. Few species are however able to adapt to all levels of salinity. They can therefore be found anywhere in an estuary (Roland and Kathleen, 2006).

The salinity of water in an estuary also allows for the flocculation of particles in the estuary. Flocculation refers to the aggregation of particles into larger clumps. When particles dissolved in freshwater enter an estuary and get into contact with salt water, they sometimes clump together. This usually, increases turbidity in the estuary (Roland and Kathleen, 2006).

Salinity apart from determining the types of plant and animal species that survive in estuaries and aiding in flocculation is also very important in monitoring many important water quality variables in estuaries. This is because, salinity levels affect most of these variables. For instance, as the salinity of water increases, the amount of oxygen it can hold decreases. It is thus important to take the salinity level into account when monitoring the dissolved oxygen of an estuary (Roland and Kathleen, 2006).

The salinity of an estuary may however be influenced by the level and intensity of the tides, the seasons and obstructions to saline water intrusion. The salinity levels of estuaries are likely to reduce during rainy seasons and increase during dry seasons due to the differences in freshwater discharge from the rivers. They also increase during high tides and decrease during low tides. Obstructions to the intrusion of saline water such as permanent sandbars can also lead to reduced estuarine salinity.

It is important for the salinity of estuaries to be monitored regularly because inappropriate salinity levels may lead to the invasion of nonnative plant and animal species which may in turn lead to the outbreak of diseases such as schistosomiasis.

2.2. Schistosomiasis

2.2.1. Definition, Types and Global Distribution of Schistosomiasis

Schistosomiasis according to many authors, is the second most prevalent and socio-economically devastating parasitic disease in tropical countries after malaria. It is endemic to 74 countries in Africa, South America, and Asia, where approximately 200 million people are infected and up to 800 million people are at risk to become infected (Zhou et al., 2008). The disease is perceived to be most common among children of school going age in poor rural communities with poor sanitary conditions and unsafe water supply (Gryseels et al., 2006 cited in Yirenya-Tawiah et al., 2011; Robson, 2013; Zhou et al., 2008). According to Yirenya Tawiah et al., (2011), infection intensifies in childhood, reaches its peak in the early teenage years and then begins to decline with increasing age. Also known as bilharziasis or "snail fever," schistosomiasis is a waterborne parasitic infection that damages internal organs, with the most common symptom being blood in urine and/or feaces and an enlarged liver. It also results in anemia, stunted growth, prolonged weakness, and sometimes premature death.

There are two forms of schistosomiasis, urinary and intestinal schistosomiasis. Urinary schistosomiasis caused by *Schistosoma haematobium* damages the bladder and kidneys, which causes painful urination, blood in the urine, and abdominal pain. The other type, intestinal schistosomiasis is caused by *Schistosoma mansoni* and damages the intestines and liver, resulting in abdominal pain, fever, and rectal bleeding.

Schistosomiasis is caused by a parasite called a schistosome which is a trematode worm with a complex life cycle (Zhou et al., 2008). At the larval stages, schistosomes reside in snails found in freshwater bodies such as ponds, dams, and slow flowing rivers. When they emerge from the infected snails, they swim in water until they penetrate the skin of people who serve as their final hosts. Once in the body of the infected person, the parasite multiplies and affects the internal organs of the individual. The infected person in turn transfers the disease to other members of the community when he or she urinates or defecates into nearby water bodies serving as sources of domestic water for people (Zhou et al., 2008).

There are five schistosome species that are adapted to humans but more than 90% of all infections are caused by just three: *Schistosoma mansoni* and *S. japonicum* which produce the intestinal disease (*Schistosoma mansoni*), and *S. haematobium*, which results in urinary schistosomiasis (*Schistosoma haematobium*). The *S. mansoni* is mainly found in Africa and South America, the *S. japonicum* in China and the Philippines while the *S. haematobium* is common in Africa and some countries in the Middle East. The two less common species adapted to humans are *S. intercalatum* in Africa and *S. mekongi* in Cambodia and Lao PDR (Zhou et al., 2008).

2.2.2. Schistosomiasis in Ghana

In the year 2007, the Ghana Health Service reported in a two year strategic plan for Integrated Neglected Tropical Diseases Control that, there has not been any recent national survey on the extent and severity of schistosomiasis. According to the report, a study conducted in the 1970s revealed that, schistosomiasis is generally endemic within communities located along rivers in all ten administrative regions of the country (GHS, 2007).

A publication by Nsowah-Nuamah et al., (2001), however noted that, the prevalence of schistosomiasis in the country ranges between 54.8% and 60.0% (Nsowah-Nuamah et al., 2001 cited in Tay et al., 2011). If that is really the case, then the disease is still a big problem in the country. In most of the literature reviewed, it is generally accepted that, the disease is most prevalent in the Volta Basin. According to the 1970 survey by the Ghana Health Service, communities in the Volta basin had prevalence rates as high as 80-90% especially in communities along the Volta Lake. Communities at the Volta estuary also had high infection rates of 76.2% (GHS, 2007).

The prevalence of schistosomiasis in the basin is largely attributed to the construction of the Akosombo and Kpong dams on the Volta River. For example, Nkegbe (2010) in his study of the prevalence of schistosomiasis among school children in the lower Volta basin indicated that, a study conducted between 1959 and 1956 by a unit of the Ghana Health Service revealed that, schistosomiasis was not present in many communities living close to the Volta River. After the creation of the Volta Lake however, the disease began to spread (Nkegbe, 2010).

Many other authors including, Gordon (2006) and Yirenya-Tawiah et al., (2011), attested to the fact that the creation of the Akosombo and Kpong Dams on the Volta River led to the spread of the disease in surrounding communities. Yirenya-Tawiah et al. (2011) stated that, soon after the construction of the Akosombo Dam, it was observed in 1966 that, there was intense transmission of the disease in the flooded valleys of the Afram and other tributaries of the Volta River.

Schistosoma haematobium, the schistosome species which causes urinary schistosomiasis, is known to be the most common in Ghana. It is found in most parts of the country making it a major public health concern (McCullough and Ali, 1965; Onori et al., 1963; Aboagye and Edoh, 2009; Bosompem et al., 2004 cited in Yirenya-Tawiah et al., 2011). Aboagye and Edoh (2009), again reported that a study by Aryeetey et al. (2000) showed that, the prevalence of urinary schistosomiasis in some communities close to the Densu river is very high and ranged between 54.8% and 60.0% (Aboagye and Edoh, 2009). Tay et al. (2011) in their survey on the Prevalence of *S. haematobium* infection at Kumasi South Hospital revealed that, there was a 40.2% infection rate in the communities close to the hospital. A study by Aboagye and Edoh (2009) also revealed a 58% and 49% prevalence rate for Mahem and Galilea communities respectively in the Greater Accra Region. The results of a study conducted by Yirenya-Tawiah et al. (2011) on urinary schistosomiasis among adults in the Volta basin also revealed an overall prevalence rate of 46.5%. All these studies reveal the severity of the disease in Ghana and the fact that it is widely distributed across the country.

The *Schistosoma mansoni* which causes the intestinal schistosomiasis is also prevalent in Ghana. Many studies have recorded its existence except that, its infection is on a smaller scale as compared to that of *Schistosoma haematobium.* Bosompem et al. (2004) identified it as one of the two parasites responsible for the disease in the country (Yirenya-Tawiah et al. 2011). Gordon (2006), also indicated that, *Biomphalaria pfeifferi* the snail intermediate host of the *Schistosoma mansoni* is one of the schistosome snails available in the Volta basin. According to him, intestinal schistosomiasis is on the increase in the lower Volta Basin to the extent that, within a period of four years, the prevalence rate of the disease had accelerated from 6% to 53.3 % (Gordon, 2006).

2.2.3. Schistosome snails and the conditions under which they survive

Schistosomes during their larval stage reside in some types of snails found in freshwater bodies. These snails serve as intermediate hosts for the parasite. The snails belong to three genera, *Bulinus, Biomphalaria and Oncomelania* (WHO, 1988). The *Bulinus and Biomphalaria* are aquatic snails which are unable to survive outside water, the *Oncomelania* on the other hand is an amphibious snail and thus can survive in and out of water (WHO, 1988). *Biomphalaria* serves as the intermediate host of *S. mansoni* and are found in Africa and the Americas whilst the *Bulinus* serve as intermediate host of *S. haematobium* in Africa and the Eastern Mediterranean (WHO, 1988). Each of the genera of snails have several species.

Snail vectors of schistosomiasis live in freshwater bodies such as ponds, dams, marshes, lakes, slow moving streams and irrigation canals (WHO, 1988; Yirenya-Tawiah et al., 2011) which have abundant aquatic plants. They attach themselves to the water plants for food and protection against high water currents and predators such as birds and fish (Yirenya-Tawiah et al., 2011). The plants also serve as a surface on which they lay their eggs (Ofori, 1999 cited in Yirenya-Tawiah et al., 2011).

The survival and population of the snails depend on a number of physical and chemical factors. These factors include, food supply, temperature, flow rate, water depth, turbidity, salinity, conductivity, pH, dissolved oxygen among many others (WHO, 1988; Ayanda, 2009; Opisa et al., 2011; Yirenya-Tawiah et al., 2011).

It is agreed by many authors that, water temperature is a key determinant of snail abundance, distribution and rate of schistosomal development in the snail vector. The positive relationship between water temperature and the snail vector density is confirmed by the studies conducted by many authors. Studies conducted by Opisa et al., in Kenya, and Yirenya-Tawiah et al., in Ghana are in agreement with this fact (Opisa et al., 2011; Yirenya-Tawiah et al., 2011). There however seems to be no uniformity in the range of temperature that favours snail abundance and distribution. Oliver and Ansari, (1967) cited in Yirenya-Tawiah et al., (2011) believed that, the snails flourish in areas where temperature ranges between 20^{o}C and 35^{o}C. An unknown author also had the view that, the best temperature range for the survival of the snails is between 22^{o}C and 26^{o}C. The World Health Organization however gave a wider range of 18^{o}C to 32^{o}C and goes on to state that, the snails develop best at 26^{o}C (WHO, 1988).

Another determinant of snail abundance and distribution is water velocity. Snails do not survive in fast flowing water bodies. This fact is confirmed by many authors. Jones (1993) cited in Yirenya-Tawiah et al. (2011) indicates that, breeding colonies of snail intermediate host are not found in fast flowing water bodies. They are rather found in water bodies with flow rates below 40cm/s. The World Health Organization however, thinks that snails are intolerant of flow rates higher than 0.7m/s (70cm/s) as well as water bodies with high levels of turbulence and waves (WHO, 1988). Where water velocity is high, snails are not able to hold on to the surfaces to which they are attached and are thus washed away. Due to the effect of flow rate, snail populations are usually higher in the dry seasons than in the rainy seasons. In the dry seasons, flow rates reduce and thus a more stable condition exists for snails to attach themselves to surfaces, feed and grow (WHO, 1965 cited in Yirenya-Tawiah et al., 2011). Water depth also affects the density and distribution of snail vectors of schistosomiasis. According to the World Health Organization, the snails seldom live in water bodies that are deeper than 1.5meters (WHO, 1988).

There seems to be no agreement between authors as to whether pH influences the abundance and distribution of snail vectors or not. According to the World Health Organization, schistosome snails tolerate a wide range of pH values (WHO, 1988). But some authors, for instance, Opisa et al. (2011), see no association between pH and snail vector density and that according to them, has been reported previously by other authors. Jordan and Webbe, (1982) cited in Yirenya-Tawiah et al., (2011) however, believed that, schistosome snails do not tolerate low pH values. On the contrary, Opisa et al., (2011), thinks that, lower pH values favour the abundance of snails. This is an issue that must be resolved through further research with focus on the relationship between pH and snail vector density.

Snails need oxygen for their metabolic activities, (WHO, 1965). Dissolved oxygen is thus another factor that influences the abundance and distribution of snail vectors. Harman and Berg, (1971), cited in Yirenya-Tawiah et al., (2011) indicated that, a dissolved oxygen concentration of between 0.40-16.00mg/l is good for the survival of snails.

The snails are usually found in areas where there is enough vegetation. Plants need sunlight to flourish, for that reason they do well in areas where the water is very transparent to allow for the penetration of sunlight. Turbidity is thus another factor that affects the survival of the snails. Very transparent water bodies support the growth of snails as turbid ones do not.

Salinity also influences snail vector abundance and distribution. The planorbid snails which intermediately host the schistosoma parasite survive in water with little or no salinity record. As a result, they are not found in oceans and salty water bodies but in freshwater bodies such as ponds, dams and many others (WHO, 1988; Yirenya-Tawiah et al., 2011).

2.3. Dredging

2.3.1. Definition and Purpose of Dredging

Dredging is the subaqueous or underwater excavation of soils and rock through the processes of excavation, vertical transport, horizontal transport, placement or use of the material dredged (Bray and Cohen, 2010).

Dredging is done for many reasons including the following:

- Navigation: Dredging is done to create or extend harbours, basins, canals, marinas and other facilities to enhance navigation.
- Environmental remediation: Dredging in recent times is done for the purpose of restoring degraded environments. It is done to remove polluted sediments or clean-up contaminated water bodies or subaqueous facilities to improve water quality. As a way of environmental remediation, mine tailing ponds and 'brownfields',

(contaminated industrial areas) for instance are dredged to make them good enough for redevelopment.

- Flood control: Dredging is also done to alter the cross-section or alignment of rivers to control their discharge or flow capabilities. This helps to reduce flooding of communities along such rivers.
- Construction materials: Dredging is also done purposely for the materials it produces. Dredged materials in the forms of sand, gravel, shell, and clay among others serve as important raw materials for the construction of industrial and residential areas, highways, dams, airports and other facilities (Bray and Cohen, 2010).

2.3.2. Dredging Equipment

There is no precise categorization of dredging equipment. There are numerous descriptive, often overlapping, terms used to categorize dredgers due to specialization and tradition (Bray and Cohen, 2010). There are thus classifications based on the means of material transport, device used for excavating sediments, the type of pumping device among many other categorizations.

With regards to the classification based on the means of material transport which is mostly referred to by authors, there are two main categories of dredgers. These are; mechanical dredgers and hydraulic dredgers. (Vlasbom, 2003a, 2003b).

Mechanical dredgers are equipment that excavate under water sediments just like dry land excavation. They actually dislodge and raise the materials to the water surface intact, "*with large pieces retaining their in-situ density and structure*". Though they can be used to dredge soft or loose materials, they are more suitable for very compacted or hard-packed ones. They are also convenient for working in confined areas. Examples of these dredgers are bucket-ladder dredgers, backhoes, and grab dredgers (Bray and Cohen 2010; Cohen, 2005b; Vlasbom, 2003b).

Hydraulic dredgers on the other hand, dislodge and remove materials from water by the use of hydraulic centrifugal pumps. They are best suited for loose, unconsolidated sediments such as loosely packed sand, silt, gravels and soft clays. Using them on very cohesive materials demand the application of teeth or water jets to break up the material. Cutter Suction dredgers for instance are hydraulic dredgers that are equipped with cutting devices to enhance their abilities to dislodge. They are thus able to excavate compacted clays, sands and rocks. The original structure and density of the materials usually change because, large amounts of water is added in the process of excavation and transport. The materials brought out of the water are therefore usually "slurry" in nature. Examples of hydraulic dredgers are, stationary suction dredgers; cutter suction dredgers; and trailing suction hopper dredgers (Bray and Cohen, 2010; Cohen, 2005b; Vlasbom, 2003a).

Apart from the mechanical and hydraulic dredgers, there are other types of dredgers which do not readily fit into any of the two categories. Notable among these ones are the 'special, low impact dredgers'. These category of dredgers have been developed as a result of the increasing need for dredging to be done in environmentally friendly ways. They are designed in such a way that, contaminated sediments can be dredged without releasing pollutants into the water column. They are also able to reduce over-dredging and minimize the suspension of sediments in water bodies. Examples of these environmentally friendly dredgers are closed clamshells, auger dredgers, disc cutters, scoop dredgers and sweep dredgers (Cohen, 2005a).

In choosing an appropriate equipment for a particular dredging project therefore, it is important for one to consider the following factors among others;

- the nature of material to be dredged
- the level of contamination of the sediment
- the physical environment at which the dredging is to be done
- the method of placement
- the distance to the placement site.

2.3.3. The Process of Dredging

Dredging involves a number of activities. These include excavation, transport and placement of material. The excavation process commonly referred to as “dredging” involves the dislodgement and removal of sediment in its natural or recently deposited condition, using appropriate equipment. Excavation can be done hydraulically or mechanically. The hydraulic method depends on the erosive power of water to work. It is mostly used in soils with less cohesion such as silt, sand and gravel. The mechanical method on the other hand refers to the use of knives, teeth or cutting edges of dredging equipment to excavate sediments. It is usually applied to cohesive soils (Cohen, 2005a; Vlasbom, 2003b).

The transport of dredged material refers to the movement of the excavated sediments to a placement site, disposal area or place of utilisation. It can also be done through hydraulic i.e through pipelines or mechanic means i.e through conveyor belts (Cohen, 2005a; Vlasbom, 2003b). The transport of the excavated materials can be accomplished by some of the dredging equipment themselves. In some cases where the equipment is incapable of transporting the materials, additional equipment such as barges, scows, and pipelines with booster pumps are used (Cohen, 2005a; Vlasbom, 2003b).

After the sediment has been excavated and transported, the final step in the dredging process is to place or dispose it off appropriately. The next section takes a look at this process into much detail.

2.3.4. Disposal of Dredged Material

The choice of management alternatives for dredged materials involves the consideration of a number of factors. Some of the factors to consider include environmental acceptability, technical feasibility, and economic feasibility of the chosen alternative.

Dredged material disposal alternatives include;

- Treatment: This refers to the processing of contaminated dredged material to reduce its quantity or to reduce the level of contamination. It involves separation techniques and incineration. In the separation techniques, contaminated mud is separated from relatively clean sand. The problem with treatment however is that, it is expensive. As a result only small volumes of contaminated materials are treated.
- Open Water Placement: This involves the disposal of the dredged material at designated sites in water bodies such as oceans, estuaries, rivers and lakes. The placement is done through the release of materials from pipelines, barges etc. Usually, sediments disposed of in this manner are not very contaminated. Where very contaminated sediments are to be disposed in open water it is important for appropriate control measures to be considered.

- Confined disposal: In this method of disposal, the dredged material is deposited in engineered containment structures, such as dikes or bunds, natural or constructed pits etc. This method isolates the sediments from surrounding waters or soils during and after placement. The placement site is referred to as “confined disposal facility", “diked disposal site” or “containment area”.
- Beneficial use applications: Most dredged materials are natural, unpolluted sediment and thus can serve as resources rather than wastes. They can be used in many ways that will benefit the environment and society. They can be used for wetland habitat development or enhancement, coastal protection, beach nourishment, mine land restoration, recreation, agriculture, island habitat, construction fill, construction material among many others (Cohen,2005b; Bray and Cohen, 2010).

2.3.5. Environmental Effects of Dredging

Dredging plays an important role in the socio-economic development and the environmental health of many communities across the globe. Like all other developmental projects however, it has some negative effects on the environment (Bray and Cohen, 2010). This section reviews relevant literature on the negative effects of dredging on the environment.

The excavation, transport and disposal of underwater sediments lead to lots of direct and indirect impacts on the environment. These effects may be felt immediately or after some years. Dredging may lead to the release of contaminants into water bodies through the disposal of sediments in these water bodies or through leaching from disposal sites. It may also increase the concentration of suspended solids in water bodies (Cohen, 2005b).

The use of heavy machines to remove and transport underwater sediments may cause high levels of noise. This noise may disturb humans and other living organisms in the area. It may drive some aquatic lives away from their original places of abode (Cohen, 2005b). Dredging modifies the aquatic environment. In the process many living organisms are killed and habitats are destroyed, leading to loss of many plant and animal species (Bray and Cohen, 2010).

It is therefore important for careful Environmental Impact Assessments (EIA) to be undertaken before any dredging project is carried out. This assessment must identify both negative and positive impacts as well as short and long term impacts on the environment and society. It is also important for such assessments to include management techniques, compensation and mitigation measures where negative effects are anticipated. Assessment prior to dredging just like all other projects must not be done without the involvement of interested groups and organizations. It is important for people who live around the place to be dredged as well as all other concerned groups to be consulted for a consensus to be reached on the various issues at stake (Cohen, 2005a).

This study therefore takes a critical look at the effects of the dredging exercise on the residents at the Volta estuary and the measures being taken to mitigate those effects.

2.4. Dams and Their Effects

If water is life then it will be sensible to say that rivers are its arteries. River basins are renowned as the cradles of civilization and cultural heritage. Ancient and modern communities alike have depended on rivers for livelihood, commerce, habitat and the ecological functions they provide (WCD, 2000).

Throughout history alterations to rivers caused by both natural and human forces have affected riverine communities in one way or another. One of the major ways in which humans alter these riverine systems is the construction of dams. Dams regulate or divert the flow of rivers, affecting the life-blood of humanity (WCD, 2000).

Nations build large dams for good reasons. Some of these reasons are to store, use and divert water for consumption, irrigation, cooling, transportation, construction, mills, power, recreation and many others. In Ghana for instance, dams have contributed immensely to national development, and there have been considerable benefits derived from them (Gordon, 2006). The construction of these dams however, has many negative impacts on ecosystems in the long run. The nature of these impacts is complex, varied and often profound in nature so that, they are usually not foreseen during the planning stage (WCD, 2000)

In the opinion of the World Commission on Dams (2000), the end of any dam project must be the sustainable improvement of human welfare. This means a significant advance of human development on a basis that is economically viable, socially equitable, and environmentally sustainable. Unfortunately, that is largely not the case.

2.4.1.1. Negative Impacts of Dams

Dams have made major contributions towards global economic growth. These contributions however, have not been devoid of negative consequences. Dams have had negative impacts on the environment, health as well as the socioeconomic life of many people across the globe. A review of relevant literature revealed the following impacts of dams.

Rivers all over the world have been transformed as a result of the construction of dams. The World Resources Institute (WRI) found that at least one large dam modifies 46% of the world’s 106 primary watersheds (WCD, 2000).

Dams affect the hydrology of rivers modifying the volume and quality of water in many rivers and degrading ecosystems. Dams alter, fragment and degrade riverine ecosystems leading to loss of biodiversity, both in the upstream and downstream. The releases or discharges of water from dams which are often unscheduled result in sudden changes in water climate disrupting seasonal migration patterns for fish and wildlife and destroying plant life (Bird, 2006). Dams also sometimes become breeding grounds for waterborne diseases such as malaria, leishmaniasis and schistosomiasis (Bird, 2006).

Damming leads to sedimentation in rivers. An estimated 0.5–1% of the total fresh water storage capacity of existing dams is lost each year to sedimentation in both large and small reservoirs worldwide. This means that 25% of the world’s existing fresh water storage capacity may be lost in the next 25 to 50 years in the absence of measures to control sedimentation (WCD, 2000).

Dams have in many cases led to the irreversible loss of species populations and ecosystems.

Growing threats to the ecological integrity of the world's watersheds come from withdrawals of water for irrigation and municipal water supply and the regulation of water flows resulting from the construction of large dams (WCD, 2000).

Among the many factors leading to the degradation of watershed ecosystems, dams are the main physical threat, fragmenting and transforming aquatic and terrestrial ecosystems with a range of effects that vary in duration, scale and degree of reversibility (WCD, 2000).

2.4.1.2. Social Impacts of Dams

While many have benefited from the services large dams provide, their construction and operation have led to many significant, negative social and human impacts. The adversely affected populations include directly displaced families, host communities where families are resettled, and riverine communities, especially those downstream of dams, whose livelihood and access to resources are affected in varying degrees by altered river flows and ecosystem fragmentation. More broadly, whole societies have lost access to natural resources and cultural heritage that were submerged by reservoirs or rivers transformed by dams (Bird, 2006; Porttinga, 1996; WCD, 2000)

The construction of large dams has led to the displacement of some 40 to 80 million people worldwide, Many of them have not been resettled or received adequate compensation, if any (WCD,2000). Between 1986 and 1993, an estimated 4 million people were displaced annually by an average of 300 large dams constructed each year (WCD, 2000).

Resettlement caused by large dams has been a significant part of total resettlement for all public infrastructure development. In China, people displaced by the construction of dams are estimated to be 27% of all people displaced by development projects. The figure is as much as 77% in India (Bird, 2006). Among World Bank funded projects involving displacement, dams and reservoirs accounted for 63% of people displaced (Bird, 2006). The control and the unscheduled releases of waters from dams threaten the lives of people living near the banks. The unannounced releases of water from the Yali Falls Dam's reservoir in Se San River of Vietnam caused the lives of 39 Cambodians (Bird, 2006). In April 2005, at least 62 Hindu pilgrims were killed when the water from the Indira Sagar dam of the state-run Narmada Hydroelectric Development Corporation was released without warning during a religious ceremony attended by an estimated 300,000 Hindus who congregated to bathe downstream from the dam on the banks of Narmada river near Dewas (Bird, 2006).

2.4.2. Dams and Estuaries.

Ecosystem transformations due to dams do not only occur in the upper, lower and mid-reaches of watersheds, they also impact on river estuaries, which are frequently complex ecosystems. They lead to the closure of the mouths of major rivers, interruption of salt intrusion, destruction of mangroves and loss of wetlands among many others (Anonymous, 2000).

Dams restrict upstream and downstream movement of migratory fish. This isolates them from vital spawning and feeding areas. Additionally damming makes most rivers unhealthy. Without healthy rivers, estuaries do not receive adequate nutrients, resulting in a reduction in the productivity of estuary waters. This accounts for significant loss of habitat in many of the world's estuaries (Anonymous, 2000).

Dams and levees inhibit the transport of sediments required to prevent coastal erosion. For example, the Mississippi River now carries only half of its original sediment load which has contributed to the extensive loss of Louisiana's wetlands. Prior to 1930, the Colorado River supplied an estimated 125-150 million tons of suspended sediment to its delta at the Gulf of California; now no sediment (or freshwater) from this river ever reaches the sea (Anonymous, 2000).

Dams and their reservoirs have been implicated in causing numerous, often negative, environmental effects such as reducing water quality, altering water temperatures and river-flows, blocking upstream and downstream fish passage, and delaying downstream migration of juvenile fishes (Ebel and Raymond 1976; Stober et al..1979; Ward and Stanford, 1987 cited in Weitkamp, 1994).

Dams are thought to affect the physical environment of the estuary primarily via flow regulation. Flow regulation reduces or prevents floods, which are important physical and biological structuring mechanisms in riverine systems by transporting large amounts of sediment through the estuary, providing physical energy for circulation, and promoting biological production.

With the suppression of large floods by dams, downstream sediment transportation decreases, estuarine production may decline, and the importance of floods as an evolutionary selective pressure diminishes. In the Columbia River estuary, the suppression of large floods is thought to be partially responsible for the currently high accretion rate in the estuary (Weitkamp, 1994).

Suppression of floods also decreases the fluvial energy available for water movement and alters circulatory patterns and salinity intrusion. The intrusion of salt water into an estuary depends on the amount of fresh water resisting the salt water because of that, decreased maximum flows and increased minimum flows regulated by dams have decreased the seasonal variability of saltwater intrusion into estuaries. Decreased variability in saltwater intrusion affects the distribution of most estuarine organisms because their distributions are determined primarily by salinity tolerance. This may have allowed range extensions or altered the distributions of many species because areas that were formerly subjected to seasonally intolerable salinity levels for those species would now be habitable throughout the year. In contrast, species which formerly held a competitive advantage because of their tolerance to highly variable salinity levels may have lost this advantage, decreasing their distribution (Weitkamp, 1994).

In addition to their effects on flow and salinity, dams impact estuarine water quality although the degree of impact and subsequent biological effects are unknown. High water volumes in a river strongly moderate water quality impacts. Activities dependent on dams, such as irrigation and industries requiring large amounts of electricity, contribute to water quality degradation by introducing contaminants into the river. These activities and the dams themselves, with their extensive reservoir storage, may also affect water temperature. Both water-quality degradation and water-temperature changes potentially affect the growth rates and health of fishes in an estuary (Weitkamp, 1994).

Dams are thought to affect water quality both directly and indirectly; however, the specific contribution of dams to present-day water-quality conditions in the estuary and the ecological significance of that contribution are not well documented (Weitkamp, 1994). Dams have a significant impact on sediment transportation in estuaries (Simenstad et al., 1992 cited in Weitkamp, 1994). This is because dams suppress peak river flows, which transport the most sediment. For instance there has been a 50% decrease in sediment and associated nutrient constituents, transport by the Columbia River at Vancouver, Washington, from 14.9 million tons (t) per year from 1868 to 1934, to 7.6 million t per year from 1958 to 1981, as well as a reduction in nutrients associated with sediment (Sherwood et al., 1990; Simenstad et al., 1992 cited in Weitkamp, 1994).

The decreased energy available from suppressed floods, paired with a decline of tidal energy caused by bathymetric changes, has decreased the ability of the estuary to move sediment seaward, and has accelerated the rate of natural sediment deposition in the estuary, resulting in the increased need for dredging (Thomas 1983; Sherwood et al., 1990; Simenstad et al., 1992 cited in Weitkamp, 1994).

Dams though very important for the survival of humans have brought about many negative environmental and socioeconomic effects. Dredging has been used as one of the ways by which some of the negative impacts can be mitigated. This study therefore investigates the effectiveness of dredging in mitigating the effects of the construction of the Akosombo and Kpong dams on the Volta estuary.

CHAPTER THREE

METHODOLOGY

3.1. Study Area

Figure 3.1: Map of the Volta Estuary Showing Sampling Sites.

3.1.1. Location and Extent of Study Area

The study was conducted at the Volta River Estuary in the Dangme East District of the Greater Accra region. The Dangme East District is located between latitudes 5°45'N and 6°00'N and Longitude 0°20'E and 0°35'E. It covers a total land area of about 909km^2, which represents almost 28% of the total land size of the Greater Accra Region (DEDA, 2012). The District is bounded by the North Tongu District to the North, South Tongu District and Dangme West District to the East and West respectively; and the Gulf of Guinea to the south. At the south-eastern side is the Volta River which extends to the Gulf of Guinea forming the Estuary, about 2 kilometers away from the District capital, Ada-Foah (DEDA, 2012).

The Volta estuary lies between the Songor lagoon in the Dangme East District and the Keta lagoon in the Volta region (Gordon and Amatekpor, 1999). The study was limited to the part of the estuary in the Dangme East District, extending from the exact point where the river enters the sea to 10 kilometers up the river. It includes all island communities found at that part of the river including; Alorkpem, Kpetsupanya, Azizakpe, Afrive, Kewunor, Adzim and many others.

3.1.2. Population and Socio-Economic Activities

According to the 2010 Population and Housing Census, the population of the Dangme East district is about 130795 people with about 70% resident in rural areas (GSS, 2010). Agriculture is the major economic activity undertaken in the district which employs about 53 % of the district's total labour force (DEDA, 2006). Agriculture provides a source of livelihood for the people through direct farming, distribution and marketing of the produce. The main agricultural activities engaged in include crop production, fishing, livestock production, and agro-forestry (DEDA, 2006).

The district is also noted for its tourism potential. Apart from the Volta estuary and the beautiful beaches available, there are other important features that attract tourists to the district including bird watching sites, marine turtle breeding sites, fetish shrines, beliefs and practices, triplet baobab tree, historical monuments and many other attractions (DEDA, 2006).

3.1.3. Physical Environment

The district is located in the Accra plains with a topography that is gently rolling. It is generally a lowland area with most areas about 60meters above sea level. Some areas of the district also lie below sea level. The highest point in the district is about 240meters above sea level. The geology of the district is mostly made of tertiary and recent deposits with a small part under the Dahomeyan complex rocks of Precambrian age.

In terms of climate, the district falls in the Ghana-Togo dry coastal equatorial zone, one of the hottest climatic regions in the country. It records high temperatures throughout the year with a range of 23-28 degree Celsius. It experiences a major rainy season between March and September where generally heavy rainfall occurs with an average of about 750ml.

The Volta River is the major surface water in the district. It runs along the south-eastern section of the district and forms part of the eastern border. The river at this point is braided into three main channels; one to the west, one to the east and another between the eastern and western channels.

The western channel has settlements such as Agokpo, Big Ada, Luhuese, Ada-foah and Azizanya along it. It has been extensively dredged by the Volta River Authority, with an average depth of 6.5meters. Settlements along the middle channel include islands such as Afrive, Adzim, Kudekekope, Alorkpem and Azizakope. The eastern channel also has island communities such as Tuanikope, and Gravedome as the major settlements along it. The middle and eastern channels have not undergone any extensive dredging. The average depth of both channels is 4.7meters.

3.2. Materials and Methods

3.2.1. Questionnaires, Interviews and Field Observations

An in-depth interview was held with a representative of the Ada Dredging Unit of the Volta River Authority (VRA) to reveal details about the dredging activities and process. It covered topics such as the purpose of the dredging, the equipment used, the dredging process, the disposal of dredged materials and the frequency of dredging. Field observation was also undertaken to confirm the description that was given.

A total of one hundred questionnaires were administered to randomly selected residents on five island communities at the estuary to acquire relevant information on how the intervention has affected them socio- economically. Questionnaire administration was done on a Sunday afternoon because interactions with some residents revealed that most people are found at home at that time. The number of respondents per community was arrived at based on the population sizes of the various communities. Thus, the community with the largest population had the highest number of respondents and the community with the least population had the lowest number of respondents. At each community, the required number of respondents were selected using the simple random sampling technique. The questions were explained to most of the people in the local languages (Dangme and Ewe) since majority of the respondents could not read and understand the English language.

The Dredge Master at Volta River Authority was also interviewed in relation to this objective. Efforts were made to get the views of the District Planning Officer of the Dangme East District Assembly and the chief of the islands Nene Pediator on the issue, but it was not successful.

Information from the questionnaires administered were analyzed using SPSS version 20.0 and Microsoft Excel. With these statistical packages, the information gathered was transformed into tables and graphs for easy understanding.

3.2.2. Analysis of Secondary Salinity Data

Salinity data spanning the period between the years 2000 and 2014 was acquired from the Volta River Authority. The data was collected in the western channel which have been extensively dredged. The sites for data collection were one kilometer apart and measurements were taken at such intervals until a record of zero (0) was obtained. At each site, salinity measurements were taken at the surface (0m), middle (2m) and bottom of the river. Measurements were done *in- situ* during the highest tide of each month. The data received was analyzed using Microsoft Excel to determine the current state of salt water intrusion in the estuary.

Trend analysis is used to test whether or not there is any pattern in data collected over time. The null hypothesis: H_0 is that there is no trend. However, any given test brings with it a precise mathematical definition of what is meant by "no trend", including a set of background assumptions usually related to type of distribution and serial correlation.

Since the data received did not conform to strict parametric assumption, the Mann-Kendall test was used to perform the trend testing. The Mann-Kendall test is used to test for trends in data if the data do not conform to a normal distribution. The outcome of the test is a "decision"- either H_0 is rejected or not rejected. Failing to reject H_0 does not mean that it was "proven" that there is no trend. Rather, it is a statement that the evidence available is not sufficient to conclude that there is a trend. Thus, the trend analysis is based on the following hypothesis

- Null Hypothesis: There is no trend
- Alternative Hypothesis: There is a trend

The decision rule is to reject the null hypothesis if $P \leq 0.05$

3.2.3. Sampling of Bilharzia Snail Vectors

Four sites were purposely selected for the determination of the density of the bilharzia vector snails in the estuary. Data was collected at two weeks intervals in the months of May and June, 2014. The nature of sampling sites and procedure for sampling are explained below.

3.2.3.1. Description of Sampling Sites

After a reconnaissance survey, interactions with stakeholders and observations, four island communities were selected for the snail sampling. The four selected communities were Kpetsupanya, Tuanikope, Afrive and Alorkpem.

3.2.3.1.1. Kpetsupanya

This community is located on the largest island in the study area. Its geographical co-ordinates are N 05.81444^{o}, E 000. 62557^{o}. It is about nine kilometers (9km) away from the estuary and is located along the western channel which has been dredged. It is one of the largest island communities with a population of about Nine hundred and nineteen (919) people according to the 2010 population census.

The shore of the river at this site is about 1.4m deep with a flow rate of about 21cm/sec. Aquatic plants such as *Ceratophyllum demersium, Eichhornia crassipes*, Mimosa pigra and *Typha domingensis* were present at the site.

3.2.3.1.2. Tuanikope

Tuanikope is more than ten kilometers (10km) away from the estuary and is located on a smaller island found along a channel which has not been dredged. Its geographical co-ordinates are N-05.82576^{o}, E-000.65921^{o}. It is a smaller community as compared to Kpetsupanya with a population of about Two hundred and seventy-eight (278) people according to the 2010 population census.

The shore where samples were taken is about 1.9m deep with a flow rate of about 15cm/sec. There was the presence of aquatic plants such as *Ceratophyllum demersium, Eichhornia crassipes,*, Mimosa pigra and *Typha domingensis* at this site.

3.2.3.1.3. Afrive

This community is about five kilometers (5km) from the sea and is located at the eastern side of the biggest island in the study area and the river channel closest to it has not been dredged. It is a small community with a population of about Two hundred and ninety-six (296) people according to the 2010 population census.

The major point of human contact at this site is about 1.2m deep. It has a flow rate of about 11cm/sec. Aquatic plants such as *Ceratophyllum demersium, Eichhornia crassippes,* Mimosa pigra and *Typha domingensis* are found in the area.

3.2.3.1.4. Alorkpem

Alorkpem is a community located on a smaller island between the central and eastern channels. It is about four kilometers (4km) from the sea and the channels around it have not been dredged. Its geographical co-ordinates are N-05.79691^{o}, E- 000.65225^{o}. It has about Seven hundred and nine (709) people occupying it according to the 2010 population census.

The average depth of the river at this site is 0.8m with a flow rate of about 18cm/sec. Aquatic plants such as *Ceratophyllum demersium, Eichhornia crassipes,* Mimosa pigra and *Typha domingensis* are present at the site.

3.2.3.2. Sampling Procedure

3.2.3.2.1. Sampling of snails

The sweep net method of sampling was adopted for the study. Sampling was done at the fringes of the river where human contact was most common. At each sampling site, a Global Positioning System (GPS) was used to identify the exact location of the place and a quadrat with an area of $100m^2$ was demarcated within which samples were randomly taken. On each day of sampling, a sweep net with a long handle, mesh size of 200µm and diameter of 19.5cm was used to sweep through the fringe vegetation in a figure of ten motions within three minutes. The contents of the net were emptied into labeled buckets after the tenth sweep. This was done in five replicates at each site.

3.2.3.2.2. Sorting the sample

Contents of the bucket were later emptied into a sorting tray along with some clean water from the river to wash out soil particles. A plastic spoon was then used to sort through the debris for snails. The *Biomphalaria and Bulinus* genus of snails were those of interest since according to the WHO (1988), these are found in Africa and Yirenya-Tawiah et al (2011), confirmed this by stating that according to Bosompem *et al*, (2004) the parasites responsible for the disease in Ghana are mainly *S. haematobium* and *S. mansoni* which are hosted by the *Bulinus* and *Biomphalaria* genus of snails respectively.

3.2.3.2.3. Determining Physico-chemical Parameters at Snail Sampling Sites

Relevant physical and chemical parameters of the water such as temperature, salinity, turbidity, flow rate, average depth, pH and dissolved oxygen were measured at each point to identify the conditions that affect the existence of the snails. Parameters such as pH, temperature, salinity, turbidity and dissolved oxygen were measured using the HORIBA multi-meter U-51 series.

The average depth was measured using a portable depth sounder and the flow rate was measured using MJP-GEOPACKS flow meter.

CHAPTER FOUR

RESULTS

4.1. Introduction

Results on the dredging process, the current nature of saline water intrusion in the Volta estuary, prevalence of the bilharzia snail vector at the estuary as well as the effects of dredging on the livelihood of island residents are presented.

4.2. A Description of the Dredging Process at the Volta Estuary

Interactions with officials of the Ada Dredging Unit of the Volta River Authority (VRA) to understand the processes involved in the dredge operations was conducted. The results of the interview have been presented under the following headings; Purpose of the dredge operations, the dredging process, success and challenges encountered in the process.

4.2.1. Purpose of Dredging at the Volta Estuary

The construction of the Akosombo and Kpong dams in 1964 and 1981 respectively, led to a considerable change in the flow characteristics of the Volta River. The original regime of high river discharge during the rainy season and low discharge during the dry season changed to a more regulated flow pattern where the river discharge is low all year round. This resulted in the formation of a permanent sandbar across the estuary due to the inability of the river to wash away the high volumes of sand that are deposited at the estuary. The sandbar interrupted the flow of salt water from the sea into the estuary, leading to many environmental challenges including the proliferation of the snail vectors of the bilharzia disease and aquatic vegetation.

In an attempt to remedy the problems, a company was contracted to investigate the situation and suggest effective measures to solve the problems. The company (AVECO Infrastructure Consultants bv. of the Netherlands) recommended that, a new opening be dredged through the sandbar to restore salt water intrusion. That led to the decision of the Volta River Authority to start the dredge operations. Thus in 1990 the Volta River Authority acquired a dredger and began dredging through the sandbar and deepening silted channels to reduce the negative effects of the Akosombo and Kpong Dams on the environment.

4.2.2. The Dredging Process at the Volta Estuary

The dredging is done using a Cutter Suction Dredger (CSD). Dredging has been going on consistently since 1990 to create an opening through the sandbar as well as deepen river channels. Cutting through the sandbar is done within six years intervals. It has thus been done in the years, 1990, 1996, 2003 and 2009. Apart from cutting through the sandbar, the channels being dredged include;

- Channel ‘A’ (estuary to Big Ada)
- Channel ‘B’ (Solikope to Pediatorkope)
- Channel ‘C’ (Solikope to Kpetsupanya)

The decision to dredge particular channels is dependent on the assessment of the Volta River Authority. The authority conducts regular surveys to identify silted portions for dredging. Apart from that, individuals are also allowed to put in request. For instance, if the members of a particular community feel that the portion of the river close to them is silted, they write to the Volta River Authority requesting that portion to be dredged. The VRA upon receiving the request, goes to assess the place and the dredging is carried out.

After dredging, the materials that are removed are deposited at the river banks to nourish the beaches. They have planned to start selling the materials to construction companies in the near future since what is excavated is mostly sand which can be used for construction purposes.

4.2.3. Success and Challenges of Dredging at the Volta Estuary

As far as the VRA is concerned, the dredging process has been highly successful. This is because most of the objectives set for the project have been met. For instance, they have been able to maintain a flood free environment and sustained a lethal salinity level of 4-6ppt for neutralizing the bilharzia colonies within a distance of nine kilometers (9km) from the estuary. This according to the Volta River Authority has led to a drastic reduction in the prevalence of bilharzia to below four percent (4%) within the dredged areas in the past years.

The major challenge however is the unavailability of adequate equipment for the operations. Arrangements are however being made to bring in additional dredgers to support the process.

4.3. Saline Water Intrusion at the Volta Estuary

Data on salinity levels at various positions of the estuary were acquired from the Volta River Authority (V.R.A) and analyzed to ascertain the current issues in saline water intrusion since dredging began. Such data was collected during the highest tide of every month at 1km intervals from the estuary until no level of salinity is recorded. Salinity levels were measured in-situ using a refractometer. At each position, salinity levels at the surface, middle and bottom waters of the river were measured at the eastern and western banks as well as in the dredged channel. This study however made use of only measurements for the surface and bottom waters in the dredged channel. Data for some years were not available.

4.3.1. Maximum Saline Water Intrusion at the Volta Estuary

In general, the farthest distance at which saline water is able to move up the river during high tides is 14km away from the sea. After that position, no record of salinity is made. Table 4.1 below shows the average salinity levels for each position at the upper water layer and bottom water layer of the estuary. The results indicate that from 2001 to 2013, the average level of salinity both at the surface and bottom of the estuary, decreases consistently as distance increases.

4.3.2. Salinity Levels in Surface Waters of the Volta Estuary

Figure 4.1 below is a line chart showing the salinity levels in surface waters of the estuary, from 2001 to 2013. The figure shows a clear decrease in salinity as one moves farther away from the estuary and reaches its lowest at the 14^{th} km mark. The highest average salinity of 25.25 ppt was recorded at the estuary and this decreases sharply to 14.35 ppt 3 kilometers away. It then decreases gradually until 0.22 ppt was recorded 14 kilometers away.

Table 4.1: Average Salinity at specific distances from the sea in parts per thousand (ppt)

	SURFACE WATERS		BOTTOM WATERS	
Distance (km)	**Mean**	**Std. Deviation**	**mean**	**Std. Deviation**
0	25.25	6.42	31.52	1.30
3	14.35	11.75	30.68	1.73
4	11.99	11.58	29.18	2.63
5	9.92	11.24	27.29	4.29
6	7.49	9.08	24.84	5.79
7	5.84	7.71	22.69	5.80
8	4.95	6.86	18.43	6.57
9	3.68	5.60	12.27	5.51
10	2.32	3.85	7.39	5.61
11	1.39	2.59	3.8	4.44
12	0.81	1.82	2.4	3.73
14	0.22	0.67	1.07	2.41

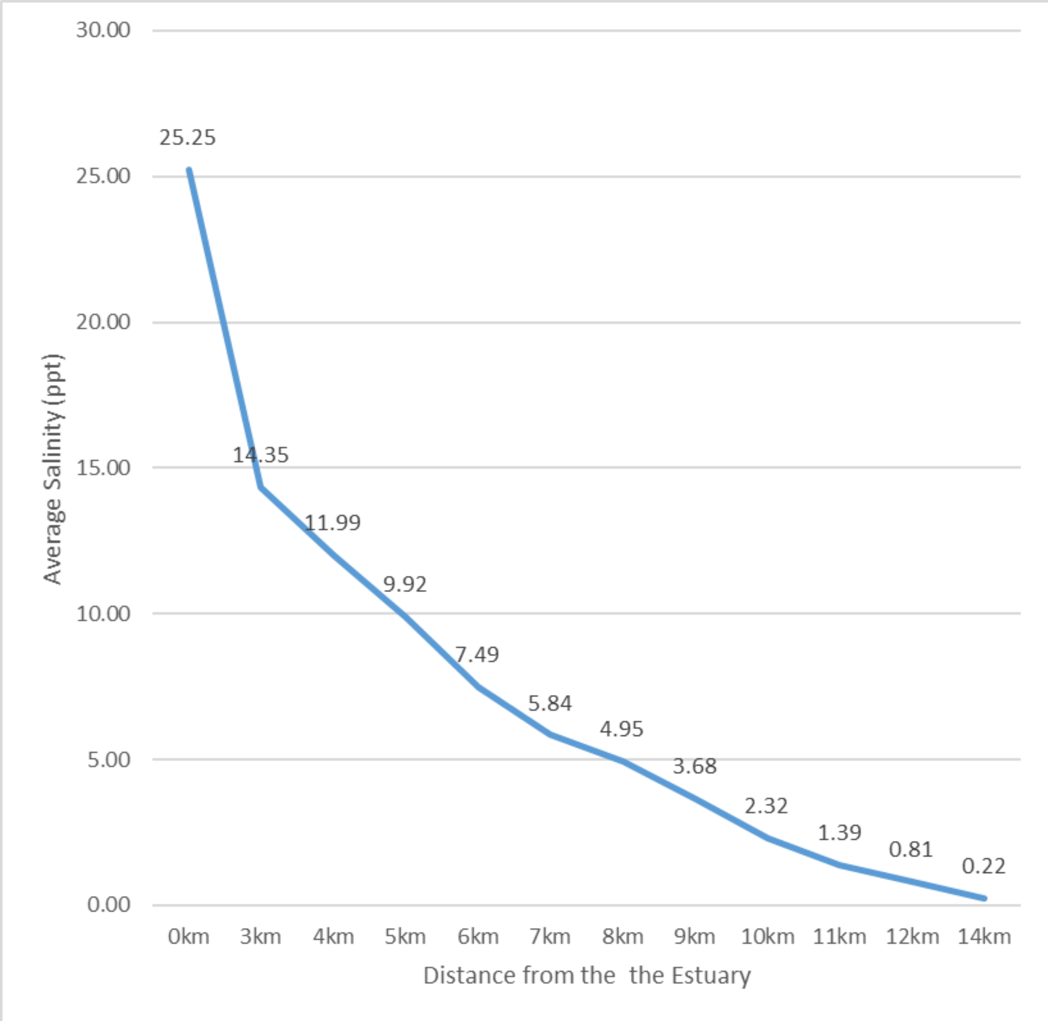

Figure 4.1: Average Salinity at the surface of the Volta Estuary measured in ppt from 2001-2013

4.3.3. Salinity levels for Bottom Waters of the Volta Estuary.

Figure 4.2 is a line chart showing the average salinity levels for bottom waters of the estuary from 2001 to 2013. The figure shows that just like the surface waters of the estuary, the average level of salinity for the bottom waters of the estuary decreases as one moves away from the sea. Salinity levels for bottom waters are however higher than those in surface waters for the same positions as expected. For instance, the highest average salinity for bottom waters was 31.52 ppt as against the 25.25 ppt recorded for surface waters.

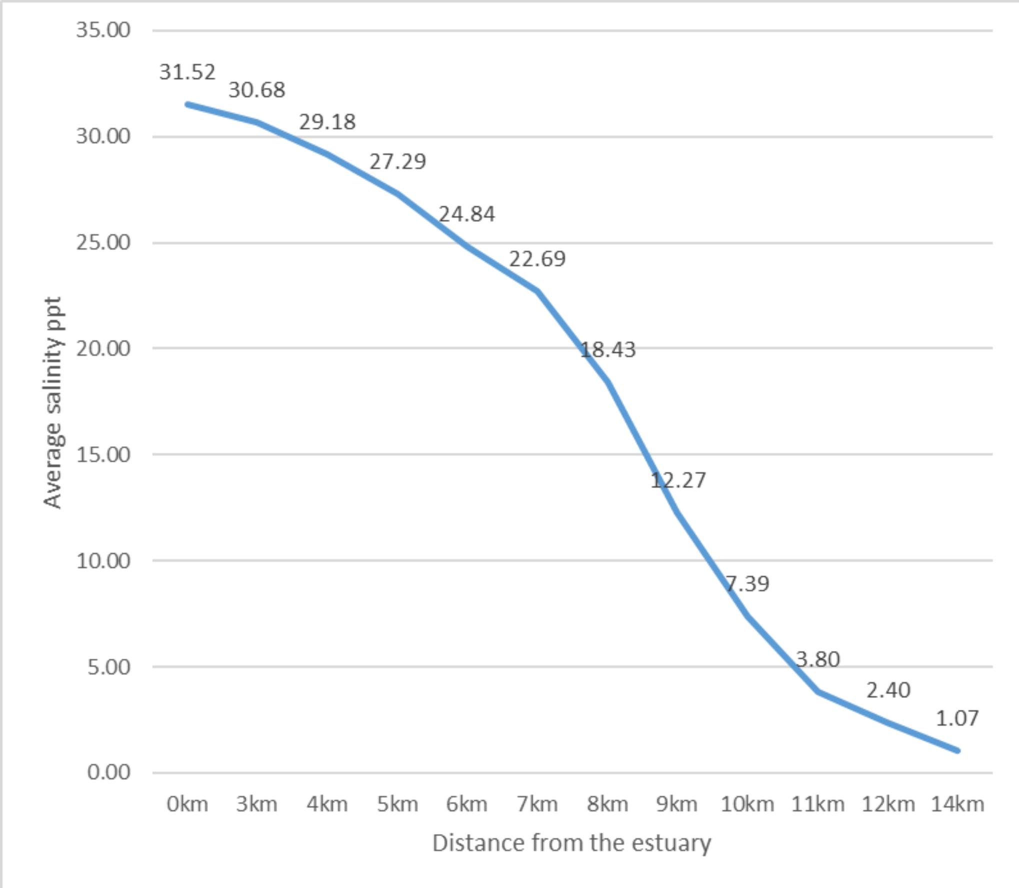

Figure 4.2: Average Salinity at the Bottom of the Volta Estuary measured in ppt. from 2001-2013

4.3.4. Trend Analysis

4.3.4.1. Trend Analysis for Salinity Values in Bottom Waters of the Estuary

Table 4.2 below shows the results of the Mann-Kendall test for trends. The results indicate that there is generally a downward trend in salinity values 0 km from the sea in bottom waters of the estuary ($P \leq 0.05$). This suggests that salinity values recorded 0 km from the sea in bottom waters of the estuary generally decreases over time. The Kendalls Tau of -0.643 suggests that salinity values for bottom waters of the estuary, is strongly negatively correlated with time. Thus, generally salinity values for bottom waters taken at places that are 0 km from the estuary are expected to decrease annually. The Sens's slope of -0.378 is an indication that salinity for bottom waters of the estuary generally decreases by an average of 0.378ppt annually. However, the table suggests that there is not much evidence to conclude that there is a trend in salinity values for bottom waters from 3km to 14km away from the sea ($P > 0.05$).

Table 4.2: Trends in Salinity values for Bottom Waters of the Volta Estuary

	0km	3km	4km	5km	6km	7km	8km	9km	10km	11km	12km	14km
Kendall's tau	-0.643	-0.400	-0.357	-0.286	-0.071	-0.214	-0.214	-0.214	-0.357	-0.357	-0.340	-0.403
p-value	0.035	0.212	0.266	0.386	0.902	0.536	0.536	0.536	0.266	0.266	0.308	0.232
alpha	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sen's slope	-0.378	-0.317	-0.686	-0.55	-0.164	-0.499	-1.16	-0.804	-0.943	-0.545	-0.347	-0.078

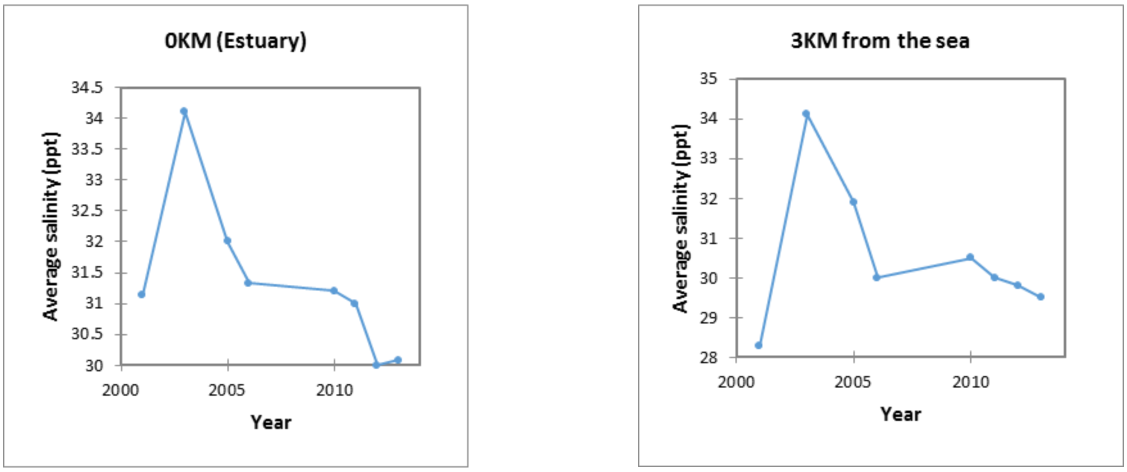

Figure 4.3: Trend Analysis for Salinity Values in Bottom Waters of the Estuary measured in ppt

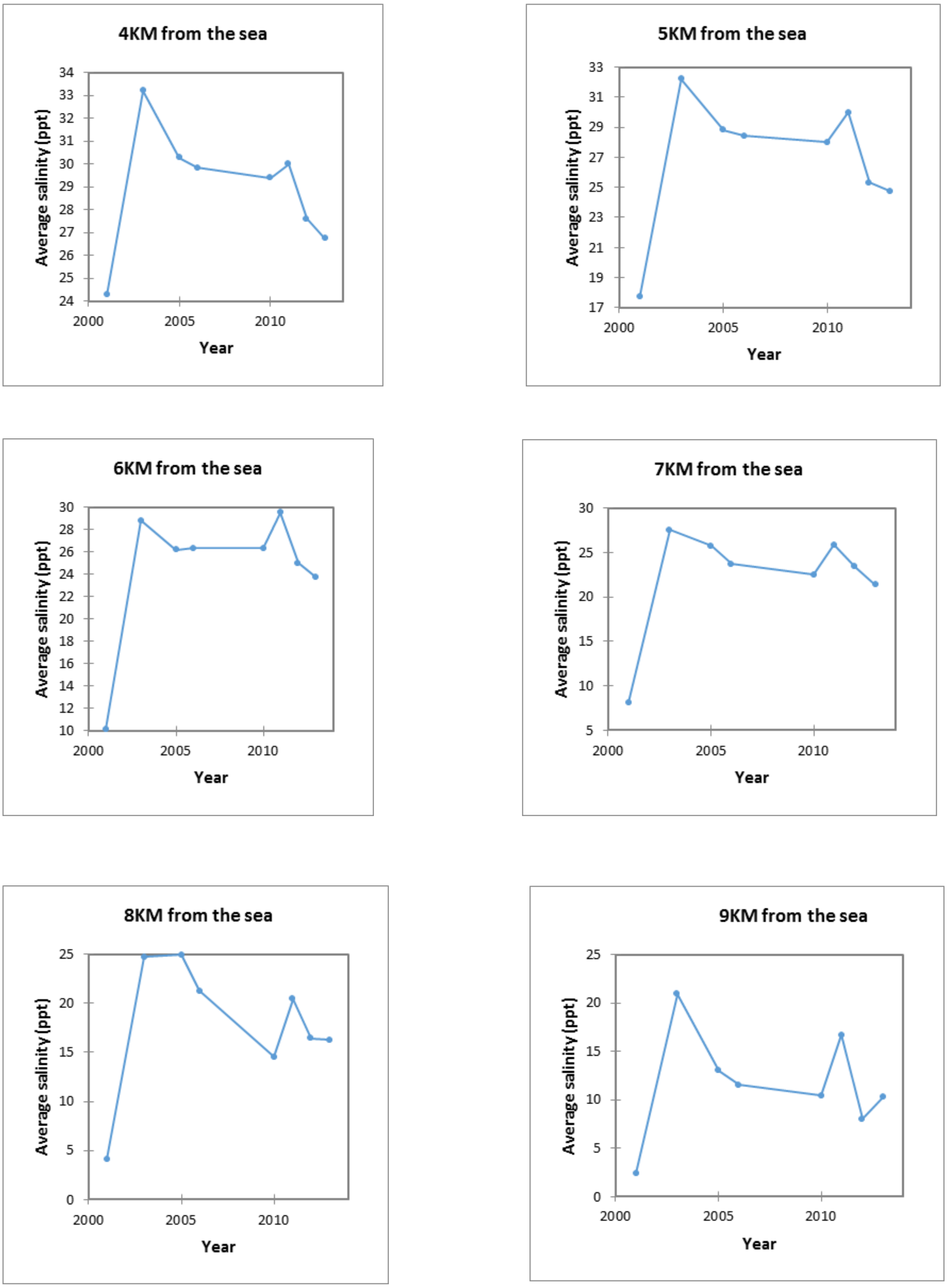

Figure 4.3. Trend Analysis for Salinity Values in Bottom Waters of the Estuary measured in ppt (continued)

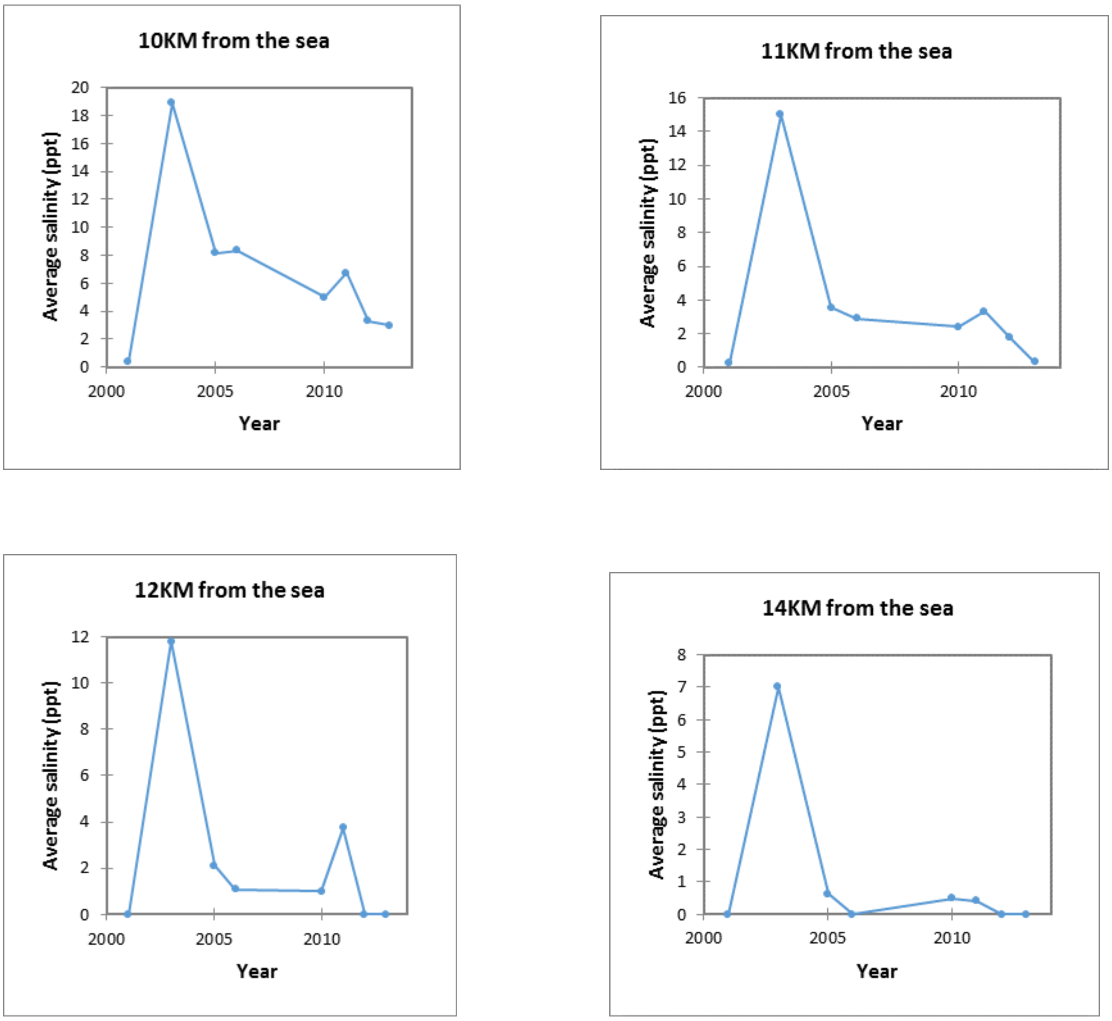

Figure 4.3. Trend Analysis for Salinity Values in Bottom Waters of the Estuary measured in ppt (Cont'd)

4.3.4.2. Trend Analysis for Salinity Values in Surface Waters of the Volta Estuary

Table 4.3 below shows the results for Mann-Kendalls test for trends. The results suggest that there is a downward trend in salinity values from 4 km to 11 km in the surface waters of the estuary ($P \leq 0.05$). This means that salinity values at 4 km to 11 km for surface waters of the estuary generally decreases over time. The table suggests that salinity values for surface waters decreases annually by an average of 3.397 ppt at 4 km, 3.313 ppt at 5 km, 2.535 ppt at 6 km, 1.646 ppt at 7 km, 1.559 ppt at 8 km, 0.77 ppt at 9 km, 0.537 ppt at 10 km and 0.261 ppt at 11 km. With regards to the following distances from the sea; 0 km, 3 km, 12 km and 14 km, the table suggests that there is little evidence to conclude that there are trends in the salinity values of surface waters. See figure 4.4 for the line charts.

Table 4.3: Trends in Salinity Values for Surface Waters of the Volta Estuary

	0km	**3km**	**4km**	**5km**	**6km**	**7km**	**8km**	**9km**	**10km**	**11km**	**12km**	**14km**
Kendall's tau	-0.222	-0.444	-0.611	-0.648	-0.667	-0.667	-0.667	-0.609	-0.609	-0.609	-0.458	-0.236
p-value (Two-tailed)	0.466	0.118	0.029	0.021	0.019	0.019	0.019	0.033	0.037	0.037	0.134	0.561
alpha	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Sen's slope(B)	-0.906	-2.31	-3.397	-3.313	-2.535	-1.646	-1.559	-0.77	-0.537	-0.261	-0.082	0

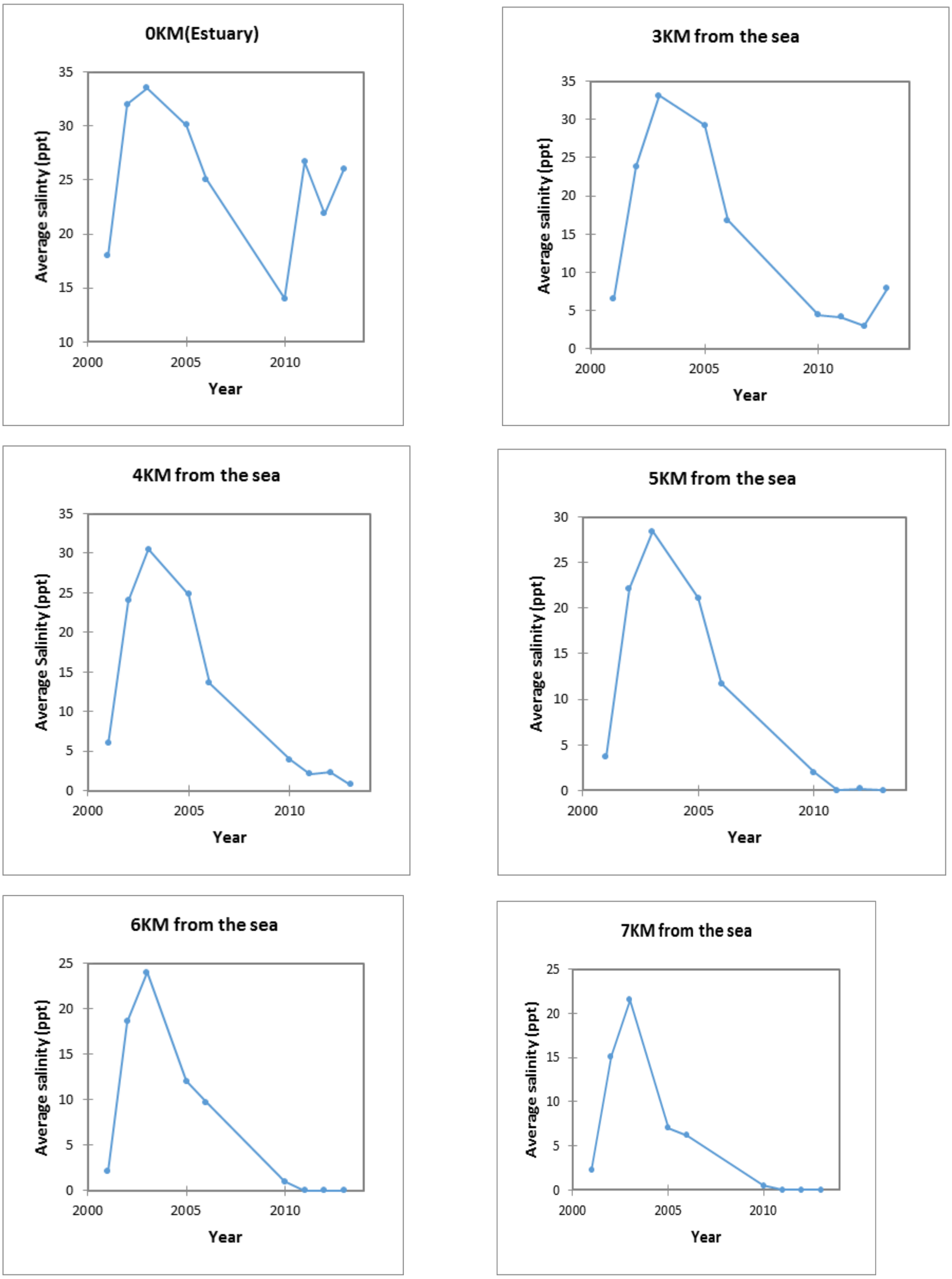

Figure 4.4: Trend Analysis for Salinity Values in Surface Waters of the Estuary measured in ppt.

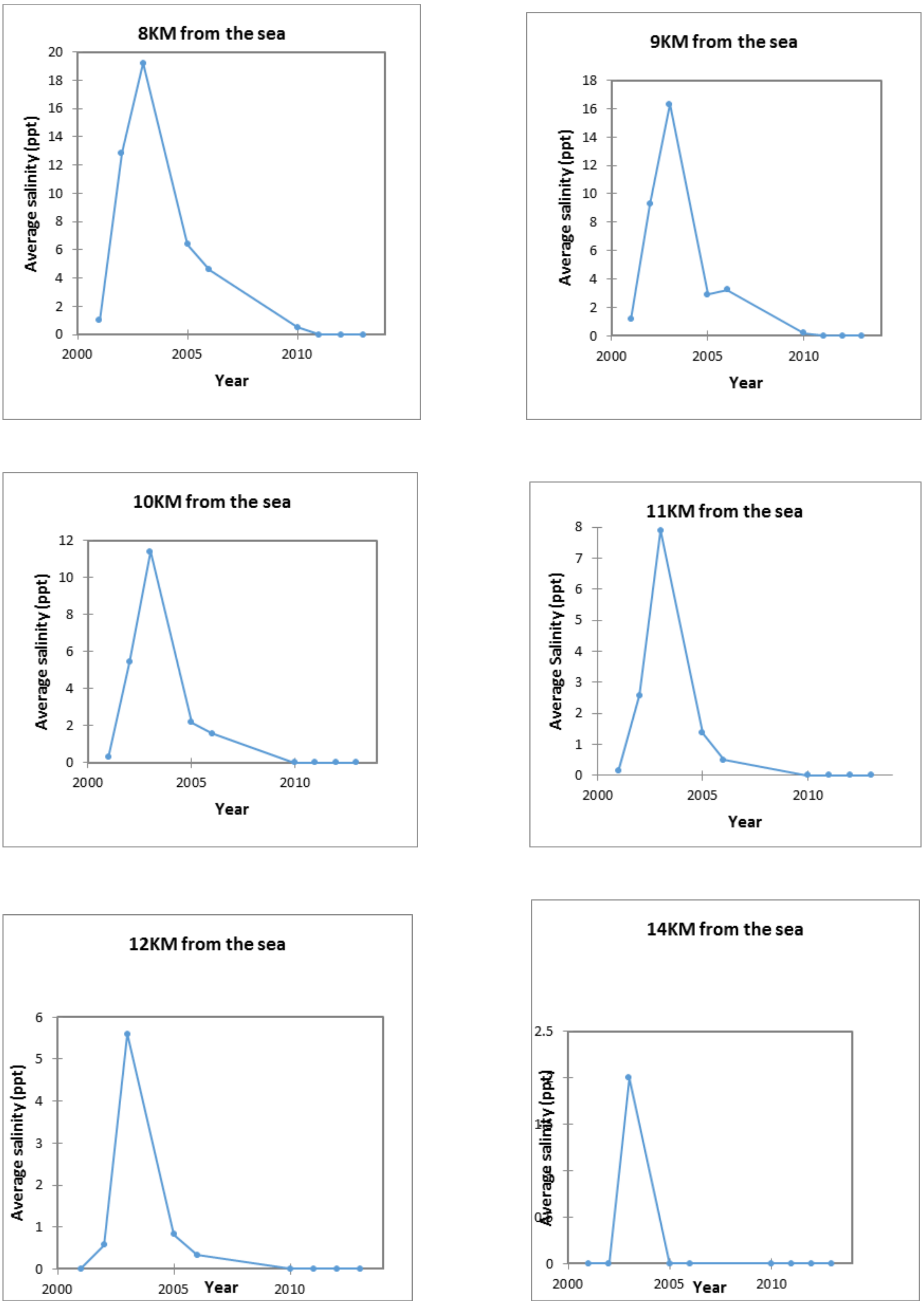

Fig. 4.4. Trend Analysis for Salinity Values in Surface Waters of the Estuary measured in ppt (Continued)

4.4. Prevalence of Schistosome Snails at the Estuary

4.4.1. Snail Collections

The *Biomphalaria and Bulinus* genus of snails were sampled to examine their prevalence at the estuary. No snail was collected throughout the study period. All the sampling sites recorded zero snail density during the four different occasions of sampling.

4.4.2. Physico-Chemical Parameters at Snail Sampling Sites

The physical and chemical parameters of the water at the sites where snails were sampled were measured just before the samples were taken. Sampling times did not coincide with the high tide periods. The physical and chemical parameters measured were temperature, pH, salinity, conductivity, Total Dissolved Solids (TDS), dissolved oxygen (DO), turbidity, average depth and flow rate of the river at each sampling site.

The mean depth at all the sites ranged between 0.8 m and 1.9 m. The mean velocity of the river at all the sites was between 11-21cm/sec. Mean water temperature was between the ranges of 25.4^{o}C and 29.2^{o}C, while mean conductivity ranged between 72 and 466µScm^{-1}. The average *p*H of the water was between 7.2 and 7.7 at all sites as average salinity ranged between 0 and 0.2ppt (these values were not taken at high tides). Turbidity was between 0.3 and 20.2 NTU while total dissolved solids were between 36 and 215mg/l at all sites. The level of dissolved oxygen was between 4.9 and 8.5mg/l at all the sites. Table 4.4 summarizes the results for the Physico-chemical parameters measured.

Table 4.4: Physico-chemical parameters at snail sampling sites at the Volta estuary

PARAMETERS	Mean values at selected sites			
	Kpetsupanya	Tuanikope	Afrive	Alorkpem
Depth (m)	1.4	1.9	1.2	0.8
Flow rate (cm/s)	21	15	11	18
Temperature(°C)	29.2	27.4	25.4	25.6
Salinity (ppt)	0	0	0.2	0.1
pH	7.5	7.7	7.2	7.4
Conductivity (μScm^{-1})	89	72	466	162
Turbidity (NTU)	20.2	4.2	5.4	0.3
TDS (mg/l)	43	36	215	74
DO (mgl-1)	8.5	4.9	5.8	6.2

4.5. Effects of Dredging On the Socio-Economic Activities of Island Residents at the Volta Estuary

Descriptive statistics involving frequency distributions, mean and standard deviations were employed for the study. One hundred questionnaires were distributed to members of the island communities surrounding the Volta estuary, out of which 95 were found usable for the study. Unanswered questions were considered missing values and were excluded from the analysis. In this regard, total frequencies which are less than 95 suggests that there are some missing values. All the analysis were done with the aid of MS Excel and SPSS version 20.

4.5.1. Demographics of Respondents

Table 4.5 explores the background information of the respondents. The table shows respondents gender, age, location, occupation and number of years in the area.

The table shows that the number of male respondents were 50 (52.6%) while the number of females were 45 (47.4%). This suggests that there was almost an equal representation of male and female respondents. Majority of the respondents were within the ages of 40 to 49 years (35.8%) as well as 60 and above (35.8%). 24.2% were within the ages of 50 and 59 and only 4 (4.2%) of the respondents were less than 40 years.

With regards to location, 31.6% of the respondents were residents of Kpetsupanya, 21% lived at Azizakpe and another 21% lived at Alorkpem, Tuanikope had 15.8% and Afrive had 10.5% of the respondents. Table 4.5 shows that majority (97.9%) of the respondents have lived in the area for more than 20 years. Only 2 (2.1%) have lived in the area for less than 20 years. This suggests that almost all the respondents have lived in the area for a considerable number of years hence they had adequate information on the subject matter of this study. Majority (38.3%) of the respondents were into trading, 33.0% were into fishing, 21.3% were farmers, and 6.4% were teachers. Only one respondent was an artisan (1.1%).

Table 4.5: Respondents Demographics

VARIABLE	FREQUENCY	PERCENT
Sex		
Male	50	52.6
Female	45	47.4
Total	**95**	**100.0**
Age		
Less than 40 years	4	4.2
40 - 49 years	34	35.8
50 - 59 years	23	24.2
60 and above	34	35.8
Total	**95**	**100.0**
Location		
Azizakpe	20	21.1
Alorkpem	20	21.1
Afrive	10	10.5
Tuanikope	15	15.8
Kpetsupanya	30	31.6
Total	**95**	**100.0**
Occupation		
Farming	20	21.3
Fishing	31	33.0
Trading	36	38.3
Teaching	6	6.4
Artisan	1	1.1
Total	**94**	**100.0**
Number of years in the area		
Less than 20 years	2	2.1
More than 20 years	92	97.9
Total	**94**	**100.0**

4.5.2. Importance of the Volta Estuary to Island Residents.

This section assesses the importance of the Volta estuary to community members. In this regard, respondents were asked whether the estuary is of any use to them. The results are displayed in table 4.6. The table shows that all 93 respondents said the estuary was very important to them. This suggests that the estuary plays an important role in the lives of individual members of the community.

Table 4.6: Usefulness of the Volta Estuary to Respondents

Response	Frequency	Percent
Yes	93	100.00

Table 4.7 shows what the estuary is used for. The table indicates that the estuary's most important use is that, it serves as a source of domestic water for the respondents (100%). The next most important use of the estuary is transportation (98.95%), followed by fishing (73.68%), recreation (47.37%) and lastly irrigation (15.79%). Thus the most important use of the estuary is that it serves as a source of domestic water. However, irrigation is the least important use of the estuary.

Table 4.7: Uses of the Estuary by Respondents.

Uses of The Estuary	N	Percent of Cases
Fishing	70	73.68%
Transport	94	98.95%
Source of domestic water	95	100.00%
Irrigation	15	15.79%
Recreation	45	47.37%

4.5.3. Effect of dredging on Fishing at the Volta Estuary

A number of questions were asked to determine the effects of dredging on fishing activities. The purpose was to compare fishing before and after dredging. Questions asked include whether they were engaged in fishing before and after dredging, the number of days they spent fishing each week before and after dredging, the types of fish available in the estuary before and after dredging etc.

4.5.3.1. Fishing at the Volta Estuary before Dredging began

Respondents were asked if they engaged in fishing activities before dredging began. The results are displayed in table 4.8 below. The table shows that 62 respondents (66.7%) were engaged in fishing before dredging began but 31 respondents (33.3%) were not engaged in fishing before dredging began. Thus majority of the respondents were engaged in fishing before dredging began.

Table 4.8: Respondents Engaged in Fishing before Dredging began

Response	Frequency	Percent
Yes	62	66.7
No	31	33.3
Total	**93**	**100.0**

Respondents who were engaged in fishing before dredging were also asked to mention the number of days they spent fishing every week. Results are presented in Table 4.9. Out of 62 respondents who went for fishing before dredging began, only 48 were able to recall the number of days they spent fishing at the time. Out of the 48 respondents, the majority (54.2%) went for fishing daily. Meanwhile, 14 respondents, representing 29.2% went for fishing 6 days in a week. 4.2% of the respondents went fishing for 2, 3, 4 and 5 days respectively. This suggests that a large percentage (83.4%) of the respondents went for fishing for 6 or 7 days (i.e.29.2% + 54.2%) in the past.

Table 4.9: Number of Days Respondents Spent Fishing before Dredging Began

Days	Frequency	Percent
2	2	4.2
3	2	4.2
4	2	4.2
5	2	4.2
6	14	29.2
7	26	54.2
Total	**48**	**100.0**

4.5.3.2. Fishing at the Volta Estuary after Dredging

Table 4.10 shows the number of respondents who were engaged in fishing after dredging. The table suggests that majority (60.2%) of the respondents were currently engaged in fishing activities while 39.8% were not. However, there had been a decline in the percentage of respondents who were currently engaged in fishing compared to that before dredging began by 6.5% (66.7% - 60.7%).

Table 4.10: Respondents Currently Engaged in Fishing Activities

Response	Frequency	Percent
Yes	53	60.2
No	35	39.8
Total	**88**	**100.0**

Table 4.11 shows the number of days the respondents currently went for fishing (after dredging began). The results suggests that majority (33.3%) of the respondents went for fishing daily, followed by 3 days (20.5%), 4 and 6 days (17.9% each) and lastly, 5 and 2 days (17.9% each). Similar to what happened in table 4.8, many people failed to answer this question.

Table 4.11: Number of Days Respondents Spent Fishing Currently.

Days	Frequency	Percent
2	2	5.1
3	8	20.5
4	7	17.9
5	2	5.1
6	7	17.9
7	13	33.3
Total	**39**	**100.0**

4.5.3.3. Comparing the Number of Days Spent on Fishing before and after Dredging

The Wilcoxon signed-rank test was employed to compare the number of days respondents went for fishing before and after dredging. The results indicate that the minimum number of days in a week that the respondents went for fishing before and after dredging is 2 while the maximum number of days that the respondents went for fishing before and after dredging is 7. However, the median number of days that the respondents went for fishing before dredging is 7 while that of after dredging is 6. The table also suggests that the 75% of the respondents went for fishing for a minimum of 6 days in a week before dredging while 75% of the respondents went for fishing for a minimum of 3 days after dredging See Table 4.12 below for more details.

Table 4.12: Descriptive Statistics: Number of Days Spent on Fishing before and after Dredging

Questions	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
How many days in a week did you spend fishing before dredging?	48	6.125	1.34678	2	7	6	7	7
How many days of the week do you spend fishing after dredging?	39	5.1026	1.74409	2	7	3	6	7

The Wilcoxon signed-rank test further reveals that 17 respondents went for fishing more days in a week before dredging began than after dredging. No respondent spent more days fishing after dredging than before dredging. 22 respondents spent the same number of days fishing before dredging and after dredging. See Table 4.13.

Table 4.13: Rank: Number of Days Spent on Fishing before and after Dredging

Ranks		N	Mean Rank	Sum of Ranks
Negative Ranks	17	9	153	
Positive Ranks	0	0	0	
Ties	22			
Total	**39**			

Further, the Wilcoxon signed-rank test (table 4.14 below) indicates that there is a significant difference in the number of days that the respondents spent on fishing before and after dredging ($Z = -3.689$, $p = 0.000$). Thus, the number of days spent on fishing had significantly decreased after dredging.

Table 4. 14: Wilcoxon signed-rank test Statistics: Number of days spent on fishing before and after dredging

Z	**-3.689**
Asymp. Sig. (2-tailed)	0.00

4.5.3.4. Comparing the types of fish caught in the estuary before and after Dredging

The respondents were asked if there were some fish varieties caught in the estuary before dredging that are not currently there. The results suggests that majority (88.5%) of the respondents indicated that there were some fish varieties caught in the estuary before dredging but are not currently there. However, 11.5% of the respondents disagreed. This is shown in table 4.15.

Table 4.15: Respondents view on whether there were some fish varieties caught in the estuary before dredging that are currently absent

Response	Frequency	Percent
Yes	77	88.5
No	10	11.5
Total	**87**	**100.0**

The respondents were further asked whether there are some fish varieties caught in the estuary currently that were previously not there. The results are displayed in Table 4.16 below. The table suggest that majority (83.1%) indicated that there are no fish varieties caught in the estuary currently that were previously not there, while 16.9% disagreed.

Table 4.16: Respondents view on whether there were fish varieties caught in the estuary currently that were previously not there.

Response	Frequency	Percent
Yes	14	16.9
No	69	83.1
Total	**83**	**100.0**

4.5.3.5. Comparing the quantity of fish in the estuary before and after Dredging

The researcher also inquired from the respondents whether the quantity of fish caught after dredging was more, less, or equal to the quantity caught before dredging. The results are shown in Table 4.17. The results show that majority (93.2%) of the respondents indicated that the quantity of fish caught after dredging was less than before dredging. 3.4% of the respondents said more, while 3.4% of the respondents indicated that the quantity is the same.

Table 4.17: Comparing Quantity of Fish Caught Currently to that before Dredging.

Quantity	Frequency	Percent
More	3	3.4
Less	82	93.2
Equal	3	3.4
Total	**88**	**100.0**

4.5.4. Effect of dredging on Farming Activities at the Volta Estuary

The researcher sought to determine the effects of dredging on farming activities. Respondents were thus asked such questions as whether they were engaged in farming before and after dredging and the number of days spent on farming before and after dredging. The responses are presented in the sections that follow.

4.5.4.1. Farming activities at the Volta Estuary before dredging

Table 4.18 shows the number of respondents engaged in farming activities before dredging. The table suggests that majority (59.8%) of the respondents were not farming before dredging while 40.2% were doing so.

Table 4.18: Respondents Engaged in Farming Activities before Dredging

Response	Frequency	Percent
Yes	35	40.2
No	52	59.8
Total	**87**	**100.0**

Table 4.19 shows the number of days spent on farming by those who engaged in farming activities before dredging. The results show that majority (61.5%) of the respondents went to the farm daily. While 19.2 % of the respondents went to the farm six times a week. 7.7 % of the respondents went to the farm for four and five days in the week. Only one respondent (3.8%) went for farming thrice in a week. In all, 80.2% of the respondents went to the farm six or seven days in a week.

Table 4.19: Number of Days Respondents Spent Farming before Dredging

Days	Frequency	Percent
3	1	3.8
4	2	7.7
5	2	7.7
6	5	19.2
7	16	61.5
Total	**26**	**100.0**

4.5.4.2. Farming at the Volta Estuary after Dredging

Table 4.20 shows the number of respondents who were engaged in farming after dredging. The results show that majority (70.4%) are not currently engaged in farming while 29.6% are. Comparing the percentage of respondents who engaged in farming before and after dredging, it can be observed that the percentage of respondents engaged in farming before dredging declined after dredging by 10.6% (40.2% – 29.6%). Thus, farming activities reduced after dredging.

Table 4.20: Respondents Engaged in Farming after Dredging

Response	Frequency	Percent
Yes	24	29.6
No	57	70.4
Total	**81**	**100.0**

Table 4.21 shows the number of days spent on farming after dredging. The results show that majority (45.5%) of the respondents worked on their farm for 7 days a week, followed by 6 days (27.3%), 5 days (13.6%), 4 days (9.1%) and lastly 3 days (4.5%).

Table 4.21: Number of Days spent on Farming by respondents currently.

Days	Frequency	Percent
3	1	4.5
4	2	9.1
5	3	13.6
6	6	27.3
7	10	45.5
Total	**22**	**100.0**

4.5.4.3. Comparing the Number of Days Spent on Farming before and after Dredging

The Wilcoxon signed-rank test was employed to compare the number of days respondents went for farming before and after dredging. The results indicate that the minimum number of days in a week that the respondents spent on farming before and after dredging began is three while the maximum number of days that the respondents spent on farming before and after dredging began is seven. However, the median number of days that the respondents spent on farming before dredging is seven while that of after dredging is six. See Table 4.22.

Table 4.22: Descriptive Statistics on The Number of Days Spent on Farming before and after Dredging

Questions	N	Mean	Std. Deviation	Min	Max	Percentiles 25th	50th (Median)	75th
How many days of the week did you spend farming before dredging?	27	6.3704	1.24493	3	7	6	7	7
How many days of the week do you spend farming after dredging?	22	6	1.19523	3	7	5	6	7

The Wilcoxon signed-rank test (Table 4.23) also shows that two respondents spent fewer days on farming after dredging than before dredging. No respondent spent more days on farming after dredging than before dredging. Nineteen respondents spent the same number of days on farming before and after dredging.

Table 4.23: Rank: Number of days spent on farming before and after dredging

	Ranks	N	Mean Rank	Sum of Ranks
Number of days spent on farming before dredging – number of days spent on farming after dredging	Negative Ranks	2[a]	1.5	3
	Positive Ranks	0[b]	0	0
	Ties	19[c]		
	Total	**21**		

a Number of days spent on farming before dredging < number of days spent on farming after dredging.
b number of days spent on farming after dredging.> Number of days spent on farming before dredging
c Number of days spent on farming before dredging = number of days spent on farming after dredging

The Wilcoxon signed-rank test (Table 4.24) shows that there is no significant difference in the number of days in a week the respondents spent on farming before and after dredging ($Z = -1.342$, $p = 0.18$). Thus regarding the respondents who engaged in farming both before and after dredging, the findings show that there was no significant change in the number of days they went to the farm in a week.

Table 4. 24: Wilcoxon signed-rank test Statistics: Number of days spent on fishing before and after dredging

Z	-1.342
Asymp. Sig. (2-tailed)	0.18

4.5.5. Effect of dredging on Tourism at the Volta Estuary

The respondents were asked if there were tourism activities in the area before dredging. The results are shown in table 4.25 below. The results show that majority (59.6%) of the respondents said that there were tourism activities before dredging while 40.4% said there were no tourism activities before dredging.

Table 4.25: Respondents view on the Existence of Tourism Activities in the area before Dredging

Response	Frequency	Percent
Yes	56	59.6
No	38	40.4
Total	**94**	**100.0**

Out of the respondents who indicated that there were tourism activities before dredging, majority (79.6%) indicated that the tourism activities were not vibrant, 15.1% said they were vibrant and 5.4% said they were very vibrant. See Table 4.26.

Table 4.26: Respondents View on How Vibrant Tourism Activities Were before Dredging

Response	Frequency	Percent
Very vibrant	5	5.4
Vibrant	14	15.1
Not vibrant	74	79.6
Total	**93**	**100.0**

Respondents were then asked to compare tourism before dredging and after dredging. The results are shown in table 4.27 below. The results show that, majority (95.8%) of the respondents said it is better, 2.1% said it is the same while 2.1% said it is worse.

Table 4.27: Respondents Comparison of Tourism Activities before Dredging to Tourism currently.

Response	Frequency	Percent
Better	91	95.8
Same	2	2.1
Worse	2	2.1
Total	**95**	**100.0**

4.5.6. Effect of Dredging on Health at the Volta Estuary

The research also sought to identify the effects of dredging on the health of the people. Table 4.28 shows the most prevalent disease among the people in the community before dredging. The results show that majority (93.33%) of the respondents perceived Bilharzia as the most prevalent disease before dredging. 2 respondents (2.22%) said Malaria was the most prevalent while 4 respondents (4.44%) indicated that Cholera was the most prevalent.

Table 4.28: Most Prevalent Disease before Dredging at the Volta Estuary

Disease	Frequency	Percent
Bilharzia	84	93.33
Malaria	2	2.22
Cholera	4	4.44
Total	**90**	**100.00**

Table 4.29 shows the current most prevalent disease from the perceptions of the respondents. The results show that, majority (50.77%) of the respondents identified Bilharzia as the current most prevalent disease. This was closely followed by Malaria (47.69%). Only one respondent (1.54%) identified Cholera as the current most prevalent disease.

Table 4.29: Current Most Predominant Disease at the Volta Estuary

Disease	Frequency	Percent
Bilharzia	33	50.77
Malaria	31	47.69
Cholera	1	1.54
Total	**65**	**100.00**

Respondents were asked to compare the current state of the Bilharzia disease to the past (before dredging). The results indicate that majority (88.04%) said it is now lower. 5.43% said it is now higher while 6.52% said it is still the same. See table 4.30 for details.

Table 4.30: Comparing the current state of Bilharzia to the past at the Volta Estuary

Response	Frequency	Percent
Higher'	5	5.43
Lower	81	88.04
Same	6	6.52
Total	**92**	**100.00**

4.5.7. Effect of Dredging on Transportation at the Volta Estuary

This section assesses the effect of dredging on transportation. Respondents were asked to assess the state of river transportation before dredging. The results are shown in table 4.31. The results show that majority (71.58%) said it was easy, 17.89% said it was a little difficult, 7.37% said it was very difficult while 3.16% said it was very easy.

Table 4.31: State of Transportation before Dredging began at the Volta Estuary

Response	Frequency	Percent
Very easy	3	3.16
Easy	68	71.58
A little difficult	17	17.89
Very difficult	7	7.37
Total	**95**	**100.00**

The respondents were further asked to compare the current state of transportation to its state before dredging. The results are shown in table 4.32. According to the table, majority (38.95%) of the respondents said it's the same. This was followed closely by 'A little better' (34.74%). 13.68% said it is much better while 12.63% said it is worse.

Table 4.32: Comparing the Current State of Transportation to the situation before dredging

Response	Frequency	Percent
Worse	12	12.63
Same	37	38.95
A little better	33	34.74
Much better	13	13.68
Total	**95**	**100.00**

The respondents who felt transportation on the river has become better believed it was due to an increment in the number of outboard motors and canoes in the communities and not the dredging activities. Those who felt transportation has become worse justified their point by the fact that, dredging has made the river deeper, making it very dangerous to travel on.

4.5.8. Effects of Dredging on Flooding at the Volta Estuary

With regards to disaster, the researcher focused on flooding. Respondents were asked whether their community got flooded at certain times before dredging. The results are shown in table 4.33. According to the table, majority (54.26%) of the respondents responded in the affirmative while 45.74% indicated that their community did not get flooded at certain times before the dredging.

Table 4.33: Respondents' View on Flooding at the Volta Estuary before Dredging.

Response	Frequency	Percent
Yes	51	54.26
No	43	45.74
Total	**94**	**100.00**

The respondents were then asked if their community gets flooded currently. Majority (62.11%) said "no" while 37.89% said "yes". The results are shown in Table 4.34.

Table 4.34: Respondents' View on Flooding at the Volta Estuary Currently

Response	Frequency	Percent
Yes	36	37.89
No	59	62.11
Total	**95**	**100.00**

The respondents were then asked to compare the current level of flooding to the level it was before dredging. The results are shown in Table 4.35. According to the table, majority (48.42%) indicated that the level of flooding has decreased. 28.42% said the current level of flooding is the same as before dredging while 23.16% said the current level of flooding has increased.

Table 4.35: Current Level of Flooding Compared to flooding before dredging at the Volta Estuary

Response	Frequency	Percent
More	22	23.16
Less	46	48.42
Same	27	28.42
Total	**95**	**100.00**

The researcher however observed that, most of the respondents who complained of flooding currently were those resident on island communities very close to the sea. These islands communities are Azizakpe and Alorkpem. The current flooding was thus not due to the river overflowing its banks but rather due to tidal effects.

4.5.9. General Assessment of the Impacts of Dredging on the Socioeconomic Lives of Island Residents at the Volta Estuary

The study looked at the general impact of dredging on the lives of the people. In this regard, the respondents were asked whether the ongoing operations have any negative effect on them. The results are shown in table 4.36 below. The table shows that majority (67.02%) of the respondents said dredging had no negative effect on them while 32.98% said it did.

Table 4.36: Respondents' View on whether Dredging has affected them negatively or not

Response	Frequency	Percent
Yes	31	32.98
No	63	67.02
Total	**94**	**100.00**

Respondents who said dredging has affected them negatively were of the view that, dredging has caused many fish varieties to migrate from the area. That has made fishing a more difficult activity than it used to be. Some also held the view that dredging has made living on the islands with children dangerous. According to them areas very close to the islands have also been dredged making those areas very deep. That according to them have led to the drowning of some children.

The respondents were further asked whether dredging has any positive effect on their lives. The results show that majority of the respondents (56.52%) indicated that dredging have had positive effects on them while 43.48% of them indicated that there were no positive effects of dredging on their lives (Table 4.37)

Table 4.37: Views of Respondents on Whether Dredging has Affected them positively or not.

Response	Frequency	Percent
Yes	52	56.52
No	40	43.48
Total	**92**	**100.00**

Respondents who answered yes to the positive effects of the dredging mentioned the reduction in the bilharzia disease as a major positive effect of the dredging activity. Majority (63.04%) of the respondents also indicated that the dredging was helpful while 31.52% indicated that it was not helpful. However, 5.43% indicated that it was very helpful. See Table 4.38.

Table 4.38: General Assessment of Dredging at the Volta Estuary

Response	Frequency	Percent
Very helpful	5	5.43
Helpful	58	63.04
Not helpful	29	31.52
Total	**92**	**100.00**

Finally, the respondents were asked if the dredge operations have made their lives in the community better. The results are displayed in table 4.39. The results show that majority (61.96%) of the respondents said 'yes' while 38.04% said 'no'.

Table 4.39: Views of Respondents on Whether Dredging Has Made Living in the Community Better.

Response	Frequency	Percent
Yes	57	61.96
No	35	38.04
Total	**92**	**100.00**

The results of the study as presented in this chapter indicates that the general objective of the study has been met.

CHAPTER FIVE

DISCUSSION

5. Introduction

The study sought to assess the effectiveness of dredging as a tool for managing the effects of sandbar development at the Volta estuary. It took a look at the dredging process, trends in saline water intrusion, density of bilharzia vector snails at the estuary and effects of dredging on the socio-economic lives of island residents.

5.1. The Dredging Process at Ada

All over the world, dredging is done for many purposes such as navigation, construction materials, flood control and environmental remediation (Bray and Cohen, 2010). Dredging for environmental remediation may involve the removal of polluted underwater sediments to improve water quality, and the restoration of environmentally degraded lands as a result of industrial activities.

The ongoing dredging at the Volta estuary can also be considered as dredging for environmental remediation though its purpose is not to remove polluted sediments. The study revealed that, the purpose of dredging at the Volta estuary is to mitigate the effects of the construction of the Akosombo and Kpong dams. What that means is that, it is supposed to clear the sandbar at the estuary in order to ensure free flow of water into the sea during high river discharge especially during occasional opening of the dams to reduce flooding of nearby communities, restore salt water intrusion which had drastically reduced to zero as a result of the development of a permanent sandbar at the estuary, as well as deepen channels to enhance transportation on the river. A restoration of salt water inflow was meant to create an environment that will be unfavourable for the proliferation of snail intermediate hosts of Schistosomiasis and in effect reduce the prevalence of the disease in the area.

There are several types of dredgers. The choice of a particular dredger for a project depends on the following factors among others; the nature of material to be dredged, the level of contamination of the sediment, the physical environment at which the dredging is to be done, the method of placement, the distance to the placement site etc.

The dredging equipment that the Volta River Authority uses for the dredging process is a cutter suction dredger. Cutter suction dredgers are hydraulic dredgers which can be stationary or self-propelled. They are equipped with a cutting device which makes it possible for them to cut hard materials into fragments. They are able to excavate all forms of materials be it sand, clay or rocks. The self-propelled ones can move over long distances even to remote areas. They work well in shallow waters and can move from one place to the other in the channels. They are flexible when it comes to the discharge of materials. The excavated materials can be transported to the placement site and discharged hydraulically through floating pipelines or barges. Cutter suction dredgers are very useful if the accuracy of the profile is of importance (Vlasbom, 2003a). Looking at the capacity of the equipment being used for the work, one can conclude that they are well equipped except for the fact that there is only one dredger which has been in use since 1990.

The dredging project at Ada is an ongoing exercise. This means that, there is continuous dredging after the very first one to maintain the situation desired. Meanwhile, the frequency of maintenance dredging is determined by the rate of siltation that occurs in the area under normal weather conditions (Bray and Cohen, 2010). The study revealed that, cutting through the sandbar by the Volta River Authority is done every six years. It is revealed in an unpublished document by the VRA that, the sand at the estuary grows at a rate of 1000 meters per annum. This suggests that, the space created at the estuary to allow for salt and fresh water interaction is about 6000 meters, and within a period of six years, the opening is closed hence the need for another dredging. The International Association of Dredging Companies (IADC) suggests that areas that demand continuous dredging be dredged beyond the required minimum depth or length in order to prolong maintenance dredging periods (Bray and Cohen, 2010). I think that will be a cost effective decision to be considered by the Volta River Authority.

Dredging at the estuary is done through the regular processes of excavation, transportation and placement of dredged materials. Dredged material placement is a big issue as far as environmental health is concerned because, inappropriate disposal methods can lead to environmental pollution. The alternatives available for dredged material disposal include, open water placement, confined disposal, treatment, and beneficial uses among others. Beneficial uses of dredged materials is a method of placement that does not see the material as a waste but rather a resource. The Volta River Authority seems to understand the fact that dredged materials are resources. This is because, the sediments according to them is being used to nourish the river banks currently. They also have plans of selling excess materials to construction companies as raw materials in future which is a good idea since it will help the Volta River Authority to generate some funds for the sustainability of the project as well as benefit those who purchase it.

5.2. Saline Water Intrusion at the Volta Estuary

Salinity is a very essential property of an estuary because, it plays several roles in ensuring that the estuary performs its functions. That of the Volta estuary got interrupted due to the development of a sandbar at the estuary after the construction of dams on the river (Gordon and Amatekpor, 1999). Dredging through the sandbar is one of the efforts being made to restore salt water intrusion. The analysis of the salinity records from 2001 to 2013 showed that, salinity of the estuary is greatly influenced by distance from the sea and depth as the situation is in most estuaries. Thus salinity decreases consistently with increasing distance from the sea and the farthest distance saline water moves up the river currently is 14 km. Even though maximum saline water intrusion of 14 km falls short of previous records of over 30 km (Pople and Rogoyska 1969), it meets the target of the Volta River Authority to sustain a lethal salinity level of 4-6ppt within 9 km distance from the estuary.

Salinity of the estuary also increases with depth at which samples are taken. The estuary may thus be seen as a salt wedge (USEPA, 1993; Levinson 1995). Average salinity taken at one kilometer intervals for bottom waters of the estuary, during high tides ranged between 31.52 ppt at the estuary itself to 1.07 ppt 14 km away from the estuary whilst that of the surface waters ranged between 25.25 ppt at the estuary to 0.22 ppt 14 km away. These average salinity levels are recorded at the highest tides. It can thus be inferred from these figures that most parts of the estuary will record zero salinity at lower tides.

The trends in salt water intrusion were analyzed. The results suggests that there is a downward trend in saline water intrusion from 4 km to 11 km in surface waters of the estuary ($P \leq 0.05$). This means that saline water intrusion at 4 km to 11 km at the top of the estuary generally decreases over time. The results showed an annual average decrease of 3.397 ppt at 4 km, 3.313 ppt at 5 km, 2.535 ppt at 6 km, 1.646 ppt at 7 km, 1.559 ppt at 8 km, 0.77 ppt at 9 km, 0.537 ppt at 10 km and 0.261 ppt at 11 km. With regards to the following distances; 0 km, 3 km, 12 km and 14 km, the results showed that there is little evidence to conclude that there are trends.

For the bottom waters of the estuary however, the study revealed that, salinity records at the estuary itself (0 km) generally decrease over time. Thus, there is a downward trend in saline water intrusion 0km for the bottom waters of the estuary ($P \leq 0.05$). The Kendalls Tau of -0.643 suggests that saline water intrusion 0 km at the bottom, is strongly negatively correlated with time, and the Sens's slope of -0.378 is an indication that, there is an average decrease of 0.378 ppt in the salinity records at the bottom of the estuary itself (0 km) annually. There is however, not enough evidence to conclude that there is a trend in saline water intrusion from 3 km to 14 km at the bottom of the estuary ($P > 0.05$).

5.3. Density of Schistosome Snails at the Volta Estuary

No snail was collected during the study even though most of the physical, chemical and biological conditions at the sites support the survival of snail vectors. Apart from Kpetsupanya which recorded 1.9 m, the mean water depth at all the sites were below 1.5 m. This means that three out of the four sites had water depths that could support the survival of the snails (WHO, 1988).

The World Health Organization records that, schistosome snails are able to survive in water velocities less than 70 cm/s, other authors also think that, a velocity below 40 cm/s is tolerated by the snails (WHO, 1988; Yirenya-Tawiah et al.; 2011). The velocity of the river at all the sites for the study fell between 11-21 cm/sec which are all within the tolerable range for the snails.

Water temperature which is considered a major determinant of snail vector abundance and distribution fell within the WHO range of 18-32 degree Celsius (WHO, 1988). The figures were between the ranges of 25.4 ^{o}C and 29.2 ^{o}C.

Other factors such as conductivity, pH, salinity, turbidity, total dissolved solids and the level of dissolved oxygen fell within acceptable limits for the survival of the snails. There was the presence of aquatic vegetation associated with the survival of schistosome snails such as *Ceratophyllum demersium*, *Echhornia crissippes*, Mimosa pigra and *Typha domingensis* at all the sampling sites.

It is therefore quite surprising that, no snail at all was found during sampling. The results could probably be explained by the periodic intrusion of saline water to the sites during high tides. As reported by Gordon and Amatekpor (1999), dredging through the sandbar and channels have allowed free flow of sea water which has in turn led to the eradication of bilharzia in the Ada area. The Volta River Authority also reported in an unpublished document that, dredging and its consequent effect on saline water intrusion has resulted in a reduction in the prevalence of bilharzia to less than 4% as of December, 1999 within the dredged area. The results of the study thus serves as a confirmation of what has been said previously.

5.4. Effects of Dredging on the Socio-economic lives of Island Residents at the Volta Estuary

There are several islands at the Volta river estuary which are inhabited by a large number of people. These residents depend on the estuary for many activities such as transportation, fishing, farming, domestic use among many others. These communities are also deprived of many social amenities such as portable water, schools, hospitals, markets and many other very important facilities needed for the survival of humans. They therefore have no option than to continuously cross to the bigger communities near the river such as Ada Foah and Big Ada to satisfy such needs. If there is any impact to be felt from the ongoing dredging at the estuary, people on the islands will be the best judges.

A study aimed at assessing the effectiveness of dredging as a tool for managing the effects of sandbar development at the estuary will thus be incomplete without getting to know the impressions of island residents. For that reason a total number of 100 questionnaires were distributed to randomly selected people on five of the islands. This section presents a discussion of the results which has already been presented in chapter four. The discussion covers subtopics such as effects on fishing, farming, transportation, flooding and tourism.

5.4.1. Effects of dredging on fishing at the Volta Estuary

Majority of the people living on the islands engage in fishing. The study revealed that, about 73.68% of the people who responded to the questionnaires saw the estuary to be useful because, they use it for fishing. Many of them have been engaged in fishing long before dredging began and are still engaged in it. As shown by table 4.8, close to 67% of the respondents were engaged in fishing before the beginning of dredging. Even though many of the respondents who were fishing before dredging began, could not really point out the average number of days they spent fishing at the time, the majority (54.2%) of those who responded went for fishing daily, 29.2% went for fishing six days in a week and 4.2% of the respondents went fishing for two, three, four and five days respectively. This suggests that a large percentage (83.4%) of the respondents went fishing for at least six out of the seven days in a week (i.e.29.2% + 54.2%) before the commencement of the dredging exercise.

Though the number of people engaged in fishing currently has reduced compared to what happened in the past, still a majority (60.2%) of the population are fisher folks. 33.3% of them went fishing on daily basis, 20.5% did so three days out of the seven days of the week 17.9% went for four and six days and finally, 5.1% went fishing five or two days out of the seven days in a week.

In comparing the number of days spent fishing before and after dredging, the results indicate that both the minimum and maximum number of days that respondents went fishing before and after dredging are the same. They went fishing for a minimum of two days and a maximum of seven days. However, the median number of days that respondents went fishing before dredging has reduced after dredging. Previously, the median number of days for fishing was seven, currently it is six. Similarly, in the past, 75% of the respondents went fishing for a minimum of six days every week, but now 75% of them went fishing for a minimum of three days. In addition, 17 respondents spent more days fishing in the past than they do now but no respondent spent more days fishing currently than before dredging. The comparison conducted, indicates that, the number of days spent on fishing had significantly decreased after dredging ($Z = -3.689$, $p = 0.000$).

With regards to the type of fish caught in the estuary before and after dredging, majority (88.5%) of the respondents indicated that some fish types were no longer found in the estuary after dredging began and 83.1% indicated that no new fish type has been identified in the estuary after dredging began.

Results of the study also showed that, the quantity of fish caught in the estuary previously is so many times more than what is there now. Most of the respondents (93.2%) agreed that the quantity of fish caught in the estuary after dredging had reduced.

One can conclude that, dredging has not affected the fishing industry in the area positively. The enquiry revealed a lot of negatives; 6.5% of respondents who went fishing before dredging have stopped, the number of days devoted to fishing by those who are still in the business have also reduced significantly, the fish varieties in the estuary have reduced and finally the quantity of fish has also reduced. There could be other reasons for all of these negative observations but, dredging cannot be completely ruled out. This is because, dredging in itself is not all good. It has negative effects, some of which include noise pollution and degradation of certain aquatic habitats (Cohen, 2005). These effects can result in the loss of some fish varieties thereby reducing the quantity of fish in the estuary.

5.4.2. Effect of Dredging on Farming Activities at the Volta Estuary

Many people on the islands were engaged in farming before dredging and are still in it after dredging. Before dredging, about 40.2% of the respondents were farming and 80.2% of them farmed six or seven days in a week. Currently, only 29.6% of the respondents farm and about 72.8% of them farm six or seven days in a week. The minimum and maximum number of days spent in the past for farming has remained the same but the median has reduced from seven days to six days. Whilst two people have reduced the number of days they use on farming, nobody has increased it.

Just like fishing, farming has not seen any improvement since dredging began. It rather seems to be dwindling. The decline may not be due to dredging, but it is an issue of concern that must be critically looked at.

5.4.3. Effect of Dredging on Tourism at the Volta Estuary

The Dangme East District is known for its tourism potential due to the presence of beaches, islands and historical monuments. The prevalence of bilharzia over the years however affected the industry. One of the purposes of the dredging exercise is to revive the tourism industry. The study also sought to know the perceptions of respondents on the effects of dredging on the tourism industry.

More than half of respondents (59.6%) agreed that, there was tourism in the area before dredging. The industry was however not vibrant according to about 79.6% of respondents. In comparing tourism before and after dredging, 95.8% of them said tourism has become better than it was before.

The improvement in tourism after dredging has turned out to be one of the most obvious positive effects of dredging. The use of dredged materials to nourish the river banks, disappearance of most aquatic weeds and reduction in the risk of bilharzia has made the area a lot more attractive to both domestic and international tourists. Efforts must be made to sustain it since the contribution of tourism to the economic development of countries all over the world cannot be overemphasized.

5.4.4. Effect of Dredging on Health at the Volta Estuary

Schistosomiasis has been a serious public health disease in the lower Volta Basin with the areas around the estuary not being an exception (Gordon & Amatekpor, 1999; Gordon, 2006; Yirenya-Tawiah et al.; 2011). Among the many attempts to control its prevalence have been manual and mechanical clearing of aquatic weeds, health education, provision of sanitary facilities to communities among others (Gordon & Amatekpor, 1999).

One of the major factors that necessitated the initiation of the dredging project was the need to eradicate schistosomiasis in the basin. This study thus sought to enquire from the residents the extent to which the dredging has affected their health especially with regards to schistosomiasis.

Majority of the respondents (93.33%) acknowledged bilharzia as the most prevalent disease in the area before dredging. With regards to the current most prevalent disease, about 50.77% of the respondents still identified bilharzia, with malaria being pointed out as the next most prevalent one by 47.69% of the respondents. Comparing the prevalence of bilharzia now to the situation before dredging, 88.04% of respondents indicated that, it has reduced.

The views of the respondents seems to be in agreement with that of the Volta River Authority who believed that, the prevalence of bilharzia has reduced to a percentage as low as 4% and Gordon & Amatekpor, who also reported the disease has been eradicated (Gordon & Amatekpor, 1999).

The fact that respondents still consider bilharzia as the most prevalent disease currently is alarming. This is because, the results of the study reveal that, there are no more snail vectors of the disease in the estuary. Other works have also created the impression that, there has been a drastic reduction in bilharzia infections. If some people still have the disease, then it is possible there are some previous infections that have not been treated. Malaria being the second most prevalent disease is also a big issue. This is because, both malaria and bilharzia have been identified as the two most serious parasitic diseases in Sub-Saharan Africa (WHO, 1988) and they have led to the death of many people. Education on the prevention of malaria should be intensified by public health officials to reduce the risk of contracting the disease.

5.4.5. Effects of Dredging on Transportation at the Volta Estuary.

The islands at the estuary have no other means of moving to other communities apart from the river. According to the Volta River Authority, the presence of aquatic weeds and the siltation of the channels were a hindrance to river transport before dredging. The study therefore sought to enquire from the residents the extent to which dredging has improved river transport.

The results show that majority (71.58%) of respondents felt transportation before dredging was easy. There however seemed to be little agreement on the current state of river transport compared to the situation before dredging. This is because, 38.95% of respondents said transportation now is the same as it was before, 34.74% said it's a little better, 13.68% said it is much better and 12.63% also felt it is rather worse.

The respondents who felt transportation on the river has become better believed it was due to an increment in the number of outboard motors and canoes in the communities; and not the dredging activities. Those who felt transportation has become worse justified their point by the fact that, dredging has made the river deeper, making it very dangerous to travel on.

Dredging has been used as a method of making river transport easier all over the world. It is rather surprising that, the situation in Ada seems different. The current river transport situation according to them is fine and it should be fine for as long as dredging continuous in the area.

5.4.6. Effects of Dredging on Flooding at the Volta Estuary

Before dredging started in 1990, areas close to the estuary were flooded in the event of water spillage from the dams. This was due to the reduced discharge capacity of the estuary at the time. Respondents were asked whether their community got flooded at certain times before dredging and the results show that, majority (54.26%) of the respondents experienced flooding in their communities in the past. 45.74% on the other hand indicated that their community did not get flooded at any time before dredging. Over

62% said they do not experience dredging currently whilst 37.89% said their communities get flooded currently.

It was observed that, most of the respondents who complained bitterly of flooding currently even though they had no flooding in the past were those resident on island communities very close to the sea. These island communities are Azizakpe and Alorkpem. The current flooding was thus not due to the river overflowing its banks but rather due to tidal effects.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1. Summary

This study sought to assess the effectiveness of dredging as a tool for managing the effects of sandbar development at the Volta estuary. Four specific objectives were to be met.

The first was to describe the ongoing process of dredging at Ada. The second, to examine the trends in saline water intrusion at the estuary. The next objective was to determine the prevalence of schistosome snails at the estuary. The final one was to assess the effects of dredging on the socio-economic lives of people resident in island communities at the estuary.

These objectives were met through the conduction of in-depth interviews and field observations, the analysis of salinity data for the period between 2000 and 2013, the sampling of snail intermediate hosts of bilharzia at the estuary, as well as the administration of questionnaires to seek the perceptions of residents with regards to the dredging exercise.

The results revealed that, dredging in Ada was necessitated by some negative effects of the construction of Akosombo and Kpong dams on the Volta River. Some of those effects include the closure of the estuary by a permanent sandbar, the proliferation of freshwater plants which served as breeding grounds for schistosome snails hence the increment of bilharzia infections among residents, a reduction in tourism activities among others. Dredging began in 1990 with the use of a cutter suction dredger. Dredging is done through the sandbar every six years to create an opening for interactions between water from the river and sea. Silted channels are also dredged to enhance the free flow of water through them. The dredged materials are put to beneficial uses such as the nourishment of river banks. They also have plans of selling the excess materials to construction companies in future. The major challenge facing the project is inadequate equipment for dredging. The current dredger is the only dredger available and it has been in use for the past 25years.

With regards to the trends in saline water intrusion, data from 2001 to 2013 were acquired from the Volta River Authority for analysis. The results showed an improvement in the extent of sea water intrusion at the estuary. Sea water now travels to areas 14 km away from the estuary itself at high tides. Average salinity at the surface of the estuary now ranges between 25.25 ppt at the main estuary to 0.22 ppt 14 kilometers away. Salinity levels at the bottom are quite higher than those at the surface for the same positions. Average salinity at the bottom ranged between 31.52 ppt at the estuary itself and 1.07 ppt 14 km away.

At the bottom of the estuary, there seems to be a downward trend in saline water intrusion at the estuary itself ($P \leq 0.05$). This suggests that the level of saline water intrusion at the bottom of the estuary generally decreases over time at the estuary itself. Thus, saline water intrusion, 0km at the bottom is generally expected to decrease annually by an average of 0.378 ppt. For areas 3 km to 14 km at the bottom of the estuary, there is not enough evidence to conclude that there are trends.

At the surface, the results suggest that there is a downward trend in saline water intrusion from 4 km to 11 km ($P \leq 0.05$). This means that saline water intrusion at 4 km to 11 km at the top of the estuary generally decreases over time. Saline water intrusion at the top decreases annually by an average of 3.397 ppt at 4 km, 3.313 ppt at 5 km, 2.535 ppt at 6 km, 1.646 ppt at 7 km, 1.559 ppt at 8 km, 0.77 ppt at 9 km, 0.537 ppt at 10 km and 0.261 ppt at 11 km. With regards to the following distances; 0 km, 3 km, 12 km and 14 km from the sea, the results suggest that there is little evidence to conclude that there are trends.

No snails were recorded at the estuary when sampling was conducted although the physical, chemical and biological parameters of the water at all the sites were within the ranges necessary for the proliferation of the snails. The mean depth at all the sites ranged between 0.8 m and 1.9 m. The mean velocity of the river at all the sites was between 11-21cm/sec. Mean water temperature was between the ranges of 25.4 ^{o}C and 29.2 ^{o}C. The average *p*H of the water was between 7.2 and 7.7 at all sites and average salinity ranged between 0 and 0.2ppt. The level of dissolved oxygen was between 4.9 and 8.5mgl^{-1} at all the sites. Aquatic plants such as *Ceratophyllum demersium, Echhornia crissippes, Mimosa pigra* and *Typha domingensis* were present at all four sampling sites.

From the perceptions of the residents of the island communities, the dredging exercise seems not to have any positive effect on the economic activities of the local people. With regards to fishing, 6.5% of those who were fishermen before the beginning of the dredging exercise have stopped. Those who are still engaged in it have also reduced the number of days they spend on it significantly. This could be due to the fact that, the quantity as well as varieties of fish in the estuary has drastically reduced compared to the situation before dredging. Farming before dredging was not the most predominant occupation in the area, but the percentage of people who engaged in it was quite high (40.2%). After dredging however, only 29.6% of the respondents farm and the number of days spent on farming has also reduced. The current unattractiveness of fishing and farming in the area currently probably explains why most of the people now identify themselves with trading. Transportation in the area has also not seen any significant contribution from the dredging exercise. River transport currently is not significantly different from what it was in the past. The little improvement now cannot be attributed to dredging but rather to the increment of outboard motors among others.

The areas where dredging seems to have made an impact were tourism and health. It is generally agreed that, tourism has become very vibrant since dredging began. This is because, the use of dredged sediments to nourish the banks have made the area more beautiful, the reduction in aquatic plants has made cruising on the river more interesting, and the reduction in the risk of bilharzia infection has made the area very attractive to both domestic and international tourists.

The risk of bilharzia infection has reduced drastically in the area. This could be due to the periodic intrusion of saline water up the river. Efforts must be made to sustain that. It however appears that, some people are still living with very old infections. This is because, some respondents still believe bilharzia is a predominant disease in the area. Malaria is also on the rise in the area. It is therefore suggested that, public health education must be intensified in the area.

Some communities close to the sea experience flooding on daily basis when the tides are high. As far as they are concerned, that was not the situation in the past. To reduce that, it would be advised that Volta River Authority uses the dredged materials to raise the banks of these islands to protect the residents from the discomfort of flooding on daily basis.

On the whole, majority of the respondents agreed that, dredging has no negative effect on them. Those who said it did, said so on the basis of the unattractive nature of the fishing industry currently. Some also held the view that, dredging has made living on the islands with children dangerous. According to them areas very close to the islands have also been dredged making those areas very deep. That according to them have led to the drowning of some children.

The island residents in general think that the ongoing dredging is helpful and thus must be continued. A few of them recommended that, dredged materials be used to raise the river banks near islands in order to prevent flooding of their communities when the tides rise. In addition, areas close to island communities should not be dredged too deep, to prevent the drowning of children.

6.2. Conclusion

The research was conducted to assess the extent to which dredging has solved the problems of poor saline water intrusion and other related problems at the Volta River estuary. It sought to describe the dredging process since this is one of its kind in the country, examine the current trends in saline water intrusion, determine the density of snail vectors of the bilharzia disease as well as assess the impacts of the dredging exercise on the socio-economic lives of people resident on islands at the estuary.

The following conclusions were drawn at the end of the project;

- The dredging exercise is being carried out through the right processes and the dredged materials are put to beneficial uses which is good for the environment.

The type of dredger being used is good except that it is only one and have been in use for the past 25 years. It may no longer be adequate for the project.

- Saline water intrusion has improved compared to what the situation was before dredging. Currently, salt water is able to move 14km up the river during high tides. Trends in salinity records however indicate a reduction in the salinity values as the years go by. This must be further looked into to identify the possible causes and how it can be solved.
- There are no more schistosome snails at the estuary. The conditions there are however suitable for their survival. Continuous efforts must be made to ensure that, the previous situation of snail abundance does not resurface.
- The dredging exercise has helped reduce the incidence of bilharzia and boosted the tourism industry. It however has not improved the socio-economic activities of the island residents. Fishing and farming which were previously the major activities of residents are giving way to trading because, they are no longer profitable ventures.

6.3. Recommendations

Based on the findings of this research, the following recommendations are to ensure that, the dredging exercise continues to the benefit of both the environment and people living at the estuary.

The Volta River Authority must explore other ways of making the dredged materials useful to community members instead of just selling it out to people outside the community. In doing that, the local residents must be engaged in discussions to arrive at the best ways of using the materials. A construction company could be established in the area to provide job opportunities for the people whose original means of livelihood are no longer attractive.

Further studies must be conducted to ascertain the causes of the downward trends in salinity records at the estuary. The Volta River Authority must also make efforts to ensure that saline water intrudes further up the river by continuously dredging silted parts of the estuary. Some island communities have the river around them very silted to the extent that, salt water never gets there even at high tides. Such people are at a risk of acquiring schistosomiasis again.

Alternative livelihood programs must be introduced in the island communities. Residents must be introduced to other ways of getting income apart from the traditional fishing and farming.

REFERENCES

Aboagye, I.F. and Edoh, D. (20O9). Investigation of the risk of infection of urinary schistosomiasis at Mahem and Galilea communities in the Greater Accra Region of Ghana. *West African Journal of Applied Ecology*. 15. 37-44.

Adjei-Boateng, D. Amisah, S. and Quagrainie, K.K. (2009). Bacteriological contamination of the freshwater clam (*Galatea paradoxa*) from the Volta estuary, Ghana. *African Journal of Microbiology Research 3*(7) 396-399

Aird, S.C. (2001). China's three gorges: The impact of dam construction on emerging human rights. *Human Rights Brief* 8, no. 2, 24-26, 36-37. Available at digitalcommons.wcl.american.edu/hrbrief/vol8/iss2/10/

Aryeetey, M. E., Wagatsuma, Y., Yeboah, G., Asante, M., Mensah, G., Nkrumah, F. K. and Kojima, S. (2000). Urinary schistosomiasis in southern Ghana: Prevalence and morbidity assessment in three (defined) rural areas drained by the Densu river. *Parasitogy International*. 49 (2): 155–163.

Ayanda, O. I. (2009). Prevalence of snail vectors of schistosomiasis and their infection rates in two localities within Ahmadu Bello University (A.B.U.) Campus, Zaria, Kaduna State, Nigeria. *Journal of Cell and Animal Biology 3* (4), 58-61.

Bird, E., (2006). Dams and development. A source of information, guidance, and weblinks related to planning and implementing dam projects. Available at www.adb.org/water

Bosompem, K. M., Bentum, I. A., Otchere, J., Anyan, W. K., Brown, C. A., Osada, Y., … and Ohta, N. (2004). Infant schistosomiasis in Ghana: A survey in an irrigation community. *Tropical Medicine and international Health* 9 (8): 917–922.

Bray, R.N. (Ed.). (2004) Dredging for development. 5th edition. IADC/IAPH. Taylor and Francis Group. London, UK.

Bray, R. N. (Ed.). (2008). Environmental aspects of dredging. IADC/CEDA.Taylor& Francis Group.London, UK

Bray, R. N., Bates, A.D. and Land, J. M. (1996). Dredging: A handbook for engineers, 2nd Edition. Butterworth-Heinemann. 1-4

Bray, R. N. and Cohen, M. R. (Eds.). (2010). Dredging for development. 6th edition. IADC/IAPH. Taylor and Francis Group. London, UK.

Cohen, M. (Ed.). (2005a). Dredging: The environmental facts. IADC/WODA/PIANC/IAPH. Taylor and Francis Group. London, UK.

Cohen, M (Ed.). (2005b). Dredging: The facts. IADC/WODA/PIANC/IAPH. Taylor and Francis Group. London, UK

Dangme East District Assembly (2012). District Profile. Available at districts.ghana-net.com

Good, J.W. (1997). Oregon CZM Profile: Protection of estuaries and coastal wetlands," unpublished report prepared as part of the National CZM effectiveness study.

Gordon, C., and Amatekpor, J.A., (Eds.). (1999)., The sustainable integrated development of the Volta basin in Ghana. Volta Basin Research Project, Accra.

Gordon, C. (2006). Dams and development Ghana. Background paper for the multi-stakeholder consultation process for dams development in Ghana. Volta Basin Research Project, Accra.

Gryseels B., Polman K., Clerinx J., and Kestens L.(2006). Human schistosomiasis. *Lancet* 368:1106–1118.

Harman W. N. and Berg C. O. (1971). The freshwater Gastropoda of central New York with illustrated keys to the genera and species. Search: *Cornell University agricultural experiment Station.* 1. 1–68.

Lowe-McConnell, R.H. (1987). Ecological studies in tropical fish communities. Cambridge University Press.

McCullough F. S. (1954). Some aspects of the investigation of schistosomiasis and its snail host in the Gold Coast. *In report of proceedings of a conference of health* *inspectors and the health superintendents held in Accra, Gold Coast, 5th and 6th August 1954.* Ghana Government Printer, Accra. 53–59.

McCullough F. S. and Ali Y. M. (1965). The distribution and prevalence of schistosoma haematobium and schistosoma mansoni in Ghana. *Ghana Medical Journal*. 4. 83–84.

Nkegbe, E. (2010). Prevalence of schistosomiasis among school children in the lower river Volta Basin in Ghana. *Gomal Journal of Medical Science*, 8, No.1

Nsowah-Nuamah, N., Mensah G., Aryeetey M.E., Wagatsuma Y., and Bentil, G., (2001). Urinary schistosomiasis in southern Ghana: A logistic regression approach to data from a community-based integrated control program. *The American Society of Tropical Medicine and Hygiene*. 65(5) 484–490

Ofori J. (1999). Water resources project & women's health. Water Research Institute (CSIR), Accra, Ghana.

Onori, E., McCullough F. S. and Rosei L. (1963). Schistosomiasis in the Volta region of Ghana. *Annals of Tropical Medicine and Parasitology*.57. 59–70.

Opisa, S., Odiere, M.R., Jura, W.G., Karanja, D.M.S. & Mwinzi,P.N.M. (2011) Malacological survey and geographical distribution of vector snails for schistosomiasis within informal settlements of Kisumu City, western Kenya. *Parasites & Vectors* 4. 226.

Pople, W. and Rogoyska, M. (1969). The effect of the Volta River Hydroelectric Project on the salinity of the lower Volta River. *Ghana Journal of Science*. 9. 9-20

Pottinger, L. (1996). Environmental impacts of large dams: African examples. Available at: http://www.internationalrivers.org/resources/environmental-impacts-of-large-damsafrican-examples-2029

Ronald, L.O. and Kathleen, M. R. (2006). Volunteer estuary monitoring: A Methods Manual. Second Edition, EPA-842-B-06-003.

Sherwood, C. R., and J. S. Creager. (1990). Sedimentary geology of the Columbia River estuary. *Progress in Oceanography*. 25: 15-79.

Tanaka, H., Nguyen, T.T. and Wada, N. (2005). Laboratory study of sand bar development at a river entrance. *Proceedings of XXXI IAHR Congress*, 3778-3787.

Tay, S.M, Amankwa, R. and Gbedema, S.Y (2011), Prevalence of schistosoma haematobium infection in Ghana: A retrospective case study in Kumasi. *International Journal of Parasitology Research.* 3, 48-52

The Ohio State University (1997). What is the ecological role of an estuary? ES-EAGLS— Life in the Great Lakes , 97-104

USEPA and USACE (1992). Evaluating environmental effects of dredged material management alternatives — A Technical Framework. EPA-842-B-92-008. http://www.epa.gov/OWOW/oceans/framework

Valle-Levinson, A. (Ed.). (2010). Contemporary Issues in Estuarine Physics. Cambrigde University Press, 1

Vlasblom, W. (2003a) Designing dredging equipment. Lecture notes, Delft University of Technology. www.dredgingengineering.com

Vlasblom, W (2003b). Introduction to dredging equipment. CEDA. Available at http://www.dredging.org/documents/ceda/downloads/vlasblom1-introduction-to-dredging-equipment.pdf.

Webbe G. (1981). Schistosomiasis: Some advances. *British Medical Journal. 283,* 1–8

Weitkamp, L. A. (1994). A review of the effects of dams on the Columbia river estuarine environment, with special reference to salmonids. *Report of the national marine fisheries service to the Bonneville power administration.* Portland, Oregon

World Health Organisation (1965). Snail control in the prevention of bilharziasis. *Report of WHO Expert Committee.* Geneva.

World Health Organisation(1993). The control of schistosomiasis. *Second report of the WHO Experts Committee.* World Health Organisation, Geneva.

World Commission on Dams (2000). Dams and development: A New framework for decision-making. Earthscan Publications Ltd, London and Sterling, VA

Yirenya-Tawiah, D. R, Abdul-Rashid, A, Futagbi, G, Aboagye, I and Dade, M. (2011): Prevalence of snail vectors of schistosomiasis in the Kpong head pond *West African Journal of Applied Ecology,* 18, 39-45

Yirenya-Tawiah, D.R., Annang, T., Otchere, J., Bentum D., Edoh D, Amoah C., Bosompem K. M (2011) Urinary schistosomiasis among adults in the Volta basin of Ghana: Prevalence, knowledge and practices. *The Journal of Tropical Medicine and Parasitology 34 (1):* 1-16

Zhou, X. N., Yang, G. J., Yang, K., Wang, X. H., Hong, Q. B., Sun, L. P., … and Utzinger, J. (2008). Potential impact of climate change on schistosomiasis transmission in China. *American Journal of Tropical Medicine and Hygiene*. 78(2):188-94

APPENDICES

UNIVERSITY OF GHANA
INSTITUTE FOR ENVIRONMENT AND SANITATION STUDIES

AN ASSESSMENT OF DREDGING AS A TOOL FOR MANAGING THE EFFECTS OF SANDBAR DEVELOPMENT AT THE VOLTA ESTUARY, ADA.

QUESTIONNAIRE FOR COMMUNITY MEMBERS

The purpose of this questionnaire is to assess the effects of the ongoing dredging on the intrusion of sea water into the Volta estuary, as well as its consequences on the environment and the livelihood and health of surrounding island communities.

Please be assured that the information received will be treated confidentially and used strictly for academic purposes.

A sincere response will be appreciated since it is very important for the success of the exercise. Thank you in advance.

Please Tick (√) and write down answers where appropriate.

SECTION A: SOCIO-DEMOGRAPHIC INFORMATION

1. Sex [1] Male [ ] [2] Female [ ]

2. Age [1] Less than 40 [ ] [2] 40 to 49 [ ]
[3] 50 to 59 [ ] [4] 60 or more [ ]

3. Location [1] Azizakpe [ ] [2] Alorkpem [ ]
[3] Afrive [ ] [4] Tuanikope [ ]
[5] Kpetsupanya [ ]

4. Occupation [1] Farming [ ] [2] Fishing [ ]
[3] Trading [ ] [4] other (specify) ……………

5. How long have you lived in this area? [1] less than 20years ☐

[2] More than 20 years ☐

SECTION B: IMPORTANCE OF THE ESTUARY TO COMMUNITY MEMBERS

6. Is the estuary of any use to you? [1] Yes ☐ [2] No ☐

If yes,

7. What do you use the estuary for?

Please Tick (√) all applicable ones.

[1] Fishing ☐

[2] Transport ☐

[3] Source of domestic water ☐

[4] Irrigation ☐

[5] Recreation ☐

[5] Other (specify) ……………………………………………..

SECTION C: EFFECTS OF DREDGING ON LIVELIHOOD

8. Were you engaged in fishing activities before the dredging began?

[1] Yes ☐ [2] No ☐

If yes,

9. How many days in a week did you spend fishing?

1	2	3	4	5	6	7

10. Do you currently engage in fishing activities

[1] Yes ☐ [2] No ☐

If yes,

11. How many days of the week do you spend fishing?

1	2	3	4	5	6	7

12. Are there some varieties of fish caught in the estuary before dredging that are currently not there?

[1] Yes ☐ [2] No ☐

If yes, give examples ……………………………………………………………

13. Are there some fish varieties caught in the estuary currently that were previously not there?

[1] Yes ☐ [2] No ☐

If yes, give examples ……………………………………………………………….

14. Compare the quantity of fish caught currently to the quantity caught before dredging?

[1] More ☐ [2] Less ☐ [3] Equal ☐

15. Were you engaged in farming activities before dredging?

[1] Yes ☐ [2] No ☐

If yes,

16. How many days of the week did you spend farming?

1	2	3	4	5	6	7

17. Are you currently engaged in farming?

[1] Yes ☐ [2] No ☐

If yes

18. How many days of the week do you spend farming?

1	2	3	4	5	6	7

19. Were there tourism activities in the area before dredging?
[1] Yes [2] No

If yes,
20. How vibrant was it?

[1] Very vibrant [2] vibrant [3] not vibrant

21. Compare tourism before dredging to tourism after dredging.

[1] Better [2] Same [3] Worse

SECTION D: EFFECTS OF DREDGING ON HEALTH

22. Which disease was the most prevalent before dredging?

[1] Bilharzia [2] Malaria [3] Guinea Worm

[4] Other (specify) ……………………………………………

23. Which disease is the most prevalent in the area currently?

[1] Bilharzia [2] Malaria [3] Guinea Worm

[4] Other (specify) ……………………………………………

24. Compare the current prevalence of the bilharzia disease to how it was before dredging

[1] Higher [2] Lower [3] Same

SECTION E: EFFECTS OF DREDGING ON TRANSPORT

25. How was river transport before dredging?

[1] Very easy ☐ [2] easy ☐ [3] a little diffi☐ [4] very ☐ difficult

Why?

……………………………………………………………………………………………

……………………………………………………………………………………………

26. How would you compare the current state of river transport to how it was before dredging?

[1] Worse ☐ [2] same ☐ [3] a little better ☐ [4] much better ☐

Why?

……………………………………………………………………………………………

……………………………………………………………………………………………

SECTION F: EFFECTS OF DREDGING ON DISASTER

27. Did your community get flooded at certain times of the year before dredging?

[1] Yes ☐ [2] No ☐

28. Does your community get flooded currently?

[1] Yes ☐ [2] No ☐

If yes,

29. Compare the current level of flooding to how it was before dredging.

[1] More ☐ [2] Less ☐ [3] Same ☐

SECTION G: GENERAL ASSESSMENT OF THE IMPACTS OF DREDGING ON THE LIVES OF LOCAL PEOPLE.

30. Do you think the ongoing dredge operations have had any negative effect on you?

[1] Yes ☐ [2] No ☐

If yes, in which ways? ……………………………………………………………

……………………………………………………………………………………

31. Do you think the ongoing dredge operations have had any positive effects on you

[1] Yes ☐ [2] No ☐

If yes, in which ways?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

32. What would be your general assessment of the dredge operations?

[1] Very helpful ☐ [2] helpful ☐ [3] not helpful ☐

33. Has it made your life in this community better?

[1] Yes ☐ [2] No ☐

SECTION H: RECCOMMENDATIONS

34. What are your recommendations for the way forward?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

Thank you very much for contributing to the success of this research. Your efforts are well appreciated.

INTERVIEW GUIDE FOR THE VOLTA RIVER AUTHORITY

PART ONE (1)

Introduction

Thank you very much for granting this interview.

The purpose of this exercise is to learn more about the ongoing dredge operations at the estuary; the extent to which it has successfully solved the problems it was intended to solve, and what effects it has on the environment and local residents.

First, I'd like to learn a little about you.

1. (a) What position do you hold in the unit?

   (b) For how long have you been serving in this position?

   (c) What are your roles as far as the dredging is concerned?

PART TWO (2)

Background to the dredge operations

2. (a) Why did the V.R.A decide to undertake dredge operations in the first place?

   (b) Was dredging the only option available?

   © If not, what were the other available options and why did you choose dredging over the others.

PART THREE (3)

Overview of the dredge operations

3. (a) For how long has the V.R.A been dredging?

(b) Can you please give me a brief overview of how the dredging is done under the following headings?

- Equipments used.
- Frequency of dredging. (please mention specific years in which dredging took place)
- Parts of the estuary being dredged etc. (please specify places that have already been dredged and those that will be dredged in the future).
- Disposal of dredged materials etc.

(c) Are there other dredgers in the area apart from the VRA dredger?

(d) What informs your decision to dredge particular portions of the estuary at particular times?

PART FOUR (4)

Success and challenges

4. (a) What are the set targets for the operation?

(b) To what extent have those targets been met?

© What are the challenges being encountered?

(c) How are you addressing those challenges?

PART FIVE

Impacts on the environment and residents

5. (a) Do you think the dredge operations have affected the environment in any way? If yes kindly highlight the effects.

   (b) In which ways do you think the operations have affected the local residents?