

Health Implications of Polluted Tilapia Consumption – The Perception of Fosu Lagoon Fishermen in Cape Coast, Ghana

Emmanuel Baffour-Awuah
Mechanical Engineering Department, Cape Coast Polytechnic, P. O. Box AD 50, Cape Coast, Ghana
*Email: emmanuelbaffourawuah37@yahoo.com

Abstract
It has long been posited that the Fosu Lagoon, located in Cape Coast in the Central Region of Ghana, is among polluted lagoons in the West African Coastal Zone. The lagoon is a habitat of many aquatic fishes, the most popular among is tilapia with zoological name saratherodon melanotheron of the chiclid family. Tilapia continues to be fished from this polluted lagoon in spite of the fact that the fishesare polluted with lead and cadmium.This paper looks at the perception of fishermen who fish in the lagoon with regards to effects of consumption of the tilapia on their health.

The purposive and snowball sampling techniques were used in selecting the sample population. Interview schedule and observation tools were applied in soliciting data from the fishermen. Both open and closed ended questions were posed in the schedule.SPSS 13 was used for the analysis. The descriptive method of analysis was employed.

Results gathered showed that fishermen did not have any idea on translocation of toxic heavy metals from water through the food chain to humans. On the average 75.5 percent of the fishermendid not perceive that tilapia consumption had negative health implications. However over 90 percent of the subjects consumed between 78g and 500g of tilapia per week.

The paper recommends that medical personnel, particularly, doctors must be involved in educating the fishermen on the health implications that may arise in the consumption of tilapia from the Fosu lagoon. Vernacular, particularly the local dialect, would be the most appropriate medium of communication in the education process.
Keywords: cadmium, health, lead, perception, pollution.

1. Introduction

Many lagoons on the globe are polluted as a result of anthropological activities (Essumang, Dodoo&Kendie, 2006). Lagoon ecosystems are habitats to aquatic plants and animals, used for agriculture, sports and recreation; salt mining, medicinal purposes, genetic research and for religious purposes among others (Cunningham &Saigo, 1997). Though these natural bodies are of great importance, they continue to face degradation to the detriment of their existence.

The Fosu lagoon, located in the Central Region of Ghana is of no exception. The fresh water resources in the lagoon continue to be polluted with various industrial waste including lead and cadmium (Essumanget.al., 2006). The delicacy of fish caught from the lagoon is popular among residents in Cape Coast. The most notated aquatic animal caught by fishermen is tilapia of zoological name *saratherodonmelanotheron* of the chiclid family. It is also referred to as the blackchin tilapia but locally as "mpatowa". This tilapia specie is the commonest fish caught from the lagoon. It is highly esteemed such that any indigenous person staying outside Cape Coast would want to have a diet of 'mpatowa' when he/she visits Cape Coast before leaving (Blay, Jnr. &Asabere-Ameyaw, 2007). Tilapia is also a source of food and protein to the fishermen. It is believed that some fishermen rely solely on tilapia from the lagoon as their major source of protein.

The pattern of human settlement planning has affected the lagoon. Geographical sites surrounding the lagoon include the Cape Coast Metropolitan Hospital, St. Augustine's College, a second cycle institution, Siwdo automobile workshops and garages,Bakaano township, and most recently, Metro Mass Transport terminal and workshop (former Omnibus Services Authority). All these contribute to pollution of the lagoon (Mohammed, 1993).

The Nkanfoa waste disposal site, Adisadel village refuse dump (Essumanget.Al. 2006), Robert Mensah Sports Stadium, all constitute in one way or another to pollution of the lagoon through leaching and surface run-offs. Garbage, night soil, metal scraps and oily discharges alsofind their way into the lagoon through these activities (Ahuahey, 2007;, Essumang et al, 2006; Adjei, 1991).

It has been established by planners, academicians and researchers that sediments, water and fish in the lagoon are heavily infected with different pollutants due to pollution caused by the activities in its sphere of influence. Heavy metals such as lead and cadmium are among these pollutants.Thus through the food chain fishermen who consume tilapia from the lagoon could ingest lead and cadmium in their body organs and tissues (Akwansah-Gilbert 2007;Dadson, 1996; Adjei 1991; Hagan, 1986; Tay, 1986).

1.1Statement of the Problem

The disposal of solid waste into drains is an attitudinal problem in Ghana and Cape Coast cannot therefore run away from that (Kendie, 1999). The low-lying terrain which the lagoon occupies has rendered it a great victim to pollution as a result of inappropriate waste disposal methods. Both solid and liquid wastes from residential, commercial and industrial activities are directly or indirectly discharged into the lagoon (Essumang et al, 2006).

Polycyclic aromatic hydrocarbons, benthic substances, nitrates and heavy metals are among the pollutants that find their way into the lagoon (Akwansah-Gilbert, 2007; Dadson, 1996; Adjei 1991; Tay, 1986). Lead and cadmium are some of the heavy metals that find their way into the lagoonas solid waste products from battery cells, paints, oils, fuel among others (Essumang et al, 2006; Abekah, 1993).

These metals could either be part of lagoon sediments or dissolve in lagoon water as metallic solution. In either of these conditions, the metals are translocated through plant tissues which are in turn fed by fishes and thereby becoming part of fish tissues. There is no doubt that fishermen who fish in the lagoon will consume some of this aquatic zoological biota including tilapia (Akwansah-Gilbert, 2007; Dadson, 1996, Adjei, 1991; Tay, 1988; Hagan, 1986). Tilapia constitutes 90% of fishes caught, according to interviews conducted with the fishermen (Aban, Asante & Falk, 2000). Through tilapia consumption therefore cadmium and lead pollutants could finally end up in body tissues of the fishermen.

Various researchers have concluded that heavy metals are present in the sediments, algae, water and fish-muscle in tilapia from the Fosulagoon (Obodai, Okyere, Boamponsem, Mireku, Aheto, &Senu, 2011; Akwansah-Gilbert, 2007;Ahuahey, 2007; Dadson, 1996; Hagan, 1986;).Some of these heavy metals, including lead and cadmium could be harmful to humans when accumulated in the human body. This brings to the fore some questionable issues. Firstly, what is the tilapia consumption rate among fishermen? Secondly, do fishermen know that toxic metals exist in the lagoon? Andthirdly, do fishermen know that consuming tilapia from the lagoon can give rise to health problems? This study sought to address these issues.

1.2Aim and objectives

The aim of this study was to investigate the perception of Fosu lagoon fishermen on the consumption of lead- and cadmium-ingested tilapia caught from the lagoon. The specific objectives, however, were as follows:

1. Estimate tilapia consumption rate among fishermen who fishedin the lagoon
2. Investigate the perception of fishermen on existence of lead and cadmium in tilapia in the lagoon.
3. Find out the perception of fishermen on negative effects of tilapia consumption as a result of lead and cadmium ingestion.

1.3Research Questions

The following research questions therefore guided the study:

1. What is the average rate at which fishermen consume tilapia from the lagoon?
2. Do fishermen perceive that tilapia in the lagoon is polluted with lead and cadmium?
3. Can tilapia from the lagoon have negative health implications on the fishermen who consume it?

1.4Scope of Study

Various studies have indicated that the Fosu lagoon is polluted with heavy metals such as cadmium and lead. It is also evidenced that tilapia in the lagoon contain lead and cadmium (Obodai et al, 2011; Dadson, 1996). This study concentrated on fishermen who fished in the lagoon. It considered those who had been consuming tilapia for the last ten years or more. Health conditions taken into consideration include infertility, cancer, painful bones and wrist drop. Other conditions considered were bluish line gum (Barton’s disease) and mentally-challenged child-birth (Pearce, 2007; Trevor, Katzung& Basters, 2007).

1.5Study Area

This study looked at the perception of fishermen who fished in the Fosulagoon in relation to lead and cadmium pollution of tilapia in the lagoon and its health effects. These fishermen werelocated in Cape Coast in the Central Region of Ghana.

Cape Coast is situated in the Cape Coast Metropolis. The metropolis is among the seventeen districts in the Central Region, Cape Coast being the capital. It is bounded to the north by Twifu-Hemang-Lower Denkyira District, south by Gulf of Guinea, east by Abura-Asebu-Kwamankese District and west by Komenda-Edina-Eguafo-Abrem District.

The main economic activities in the metropolis are services and industry. Agricultural activities include food crop cultivation.Cash crops such as orange, acacia wood-lot, teak wood lot, oil palm and coconut are also cultivated. Activities involving services are hairdressing, sewing, barbering and public services.

The major industrial activities include the AmeenSangari factory which produces soap brands and brake bands. Othersare small scale enterprises such as soap-making, food oil extraction (coconut, palm fruit and palm kernel), quarrying, lumber, *pito* brewing and automobile garages and workshops are also located in the metropolis. Fishing activities are mainly in the sea, rivers, streams, ponds and the Fosu lagoon. Figure 1 shows map of the lagoon.

Figure1: Map of Cape Coast showing Fosu Lagoon

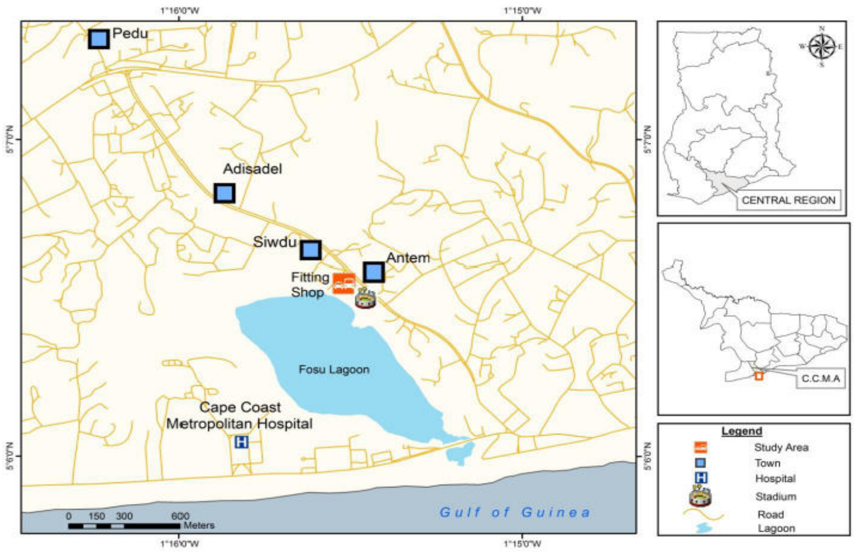

Figure 1: Map of Cape Coast showing the Fosu Lagoon.(Source: Arthur &Eshun, 2012)

2.Aquatic Pollution

Pollution may be defined as the introduction by anthropogenic or natural means into the environment of a substance or energy liable to cause hazards to human health, harm to living resources and ecological systems (Tripathy& Panda, 2003). Pollution can cause damage to structures or amenities. It may also interfere with legitimate uses of the environment by effecting changes in energy patterns and radiation levels; physical or chemical constitution or the abundance of organisms. It occurs through natural and human activities (Doe, 2007).In summary, pollution is the release of physical, chemical and biological material or wave form into the environment at such magnitude that its harmful effect can affect the healthy or comfortable existence of living organisms or the quality of non-living matter now or the future.

Basically, there are three types of pollution, air, land and water. Water pollution, also referred to as aquatic pollution, affects water bodies. But water is very important for the very survival of humanity. It is used for manifold of purposes. The human body is composed of over 70% of weight by water. It is known that about 75% of the earth's surface is also covered by water masses, including ice. This quantity of water on the earth's surface is vital in the maintenance of ecosystemic balance necessary for man's survival. For this reason, disturbance of this equilibrium such as the physical, biological and chemical composition and purity of water on the surface of the earth, will uncompromisingly affect living matter (Utz, 2000).

Any addition of any substance to water that changes its physical, biological and chemical constitution in such a way that its useful legitimate purposes are affected constitute aquatic pollution. Aquatic pollution includes water and its living and non-living organisms. Polluted water is non-potable. It may be unpleasant for drinking, have bad odor, may be turbid, and unfit for bathing, washing and/or any other beneficial purposes. Since aquatic pollution therefore affects both plants and animals, water pollution can be related to health and welfare of mankind.Chemical, physical or biological pollutants that enter rivers, lakes and lagoons can also cause serious health hazards to other living organisms (Sinha, Shukla, &Shukla, 2005).

The causes of aquatic pollution are many. It may be caused by discharges of organic waste from elevated areas. Toxic wastes from urban areas also contribute to the pollution of lakes and lagoons. In some cases, mortality rates of living organisms in water bodies may increase by 25% per annum. Toxic organic and inorganic wastes from sewage treatment plants may be discharged into aquatic bodies. Toxic and hazardous effluent and solid wastes from factories and industries such as automobile-related workshops may also find their way into water bodies (Ahuahey, 2007;Sinha et al, 2005).

Dumping of tailings and metal scraps and waste sludge from automobile-related factories, workshops and industries can make significant contribution to aquatic pollution. Silting could be caused by particles generated from heavy metals from automobile related workshops, garages and activities. Discharges and leachates of municipal wastes and industrial effluents may critically worsen water quality. These could eventually find their way into lagoon environments (Ahuahey, 2007; Essumang et al, 2006; Sinha et al, 2005).

Inorganic and organic matter may also be transported form industrial sites by streams, rivulets and surface run-offs into lakes and lagoons. Such effluents and leachates contain large volume of nitrates, phosphates (Essumang et. al.,2006) and heavy metals which can disrupt the entire water body (Hagan, 1996). Leachates from dumping sites could also pollute aquatic environments (Akwansah-Gilbert, 2007) and the Fosu lagoon is of no exception.

2.1 Heavy metal pollution in the Fosu Lagoon

The Fosu lagoon has not been sparred of the consequences of negative human behavior with various solid waste and leachates being transported through natural and human means into it (Essumang et. al., 2006). Research has proven that the lagoon, located in Cape Coast is polluted. Pollutants that find their way into it include heavy metals among others. For example, high values of copper concentrations ranging from 90 – 102 ppm were present in the lagoon (Hagan, 1986). The tolerable limit is 1ppm (Toth, Andreji, Toth, Slavic, Arvay, &Stanovic, 2012). Tay (1989) also found that copper concentrations in algae ranging from 0.19 to 1.04ppm were present in the lagoon.

As at 1986, mercury pollution stood at a maximum of 0.008 ppm (Hagan, 1986) whereas by 1989, mercury concentration in algae in the lagoon stood between 0.397 and 1.039 ppm (Tay, 1989). The average tolerable limit of mercury in fish muscle and sediments are 0.0005ppm and0.001respectively (Toth et. al., 2012). Zinc concentrations in the sediments of the lagoon ranged from 61.26 ppm to 276.96 ppm dry weight (Adjei, 1991) whiles the tolerable limit is 2.5ppm (Toth et. al., 2012).

Akwansah-Gilbert (2007) indicated cadmium, nickel, zinc, manganese and iron concentrations of 0.78-33mg/kg, 0.31–0.12mg/kg, 2.66–0.24mg/kg and 0.36g/kg respectively though these values were within the threshold values of Canadian InterimMarine/Estuarine Sediments Guidelines for the protection of aquatic lives except cadmium.The threshold for cadmiumis 0.7mg/kg.These heavy metal pollutants were generated around the auto repair shops near the lagoon as a result of careless disposal of all kinds of waste (Ahuahey, 2007; Akwansah-Gilbert, 2007). Lead acid batteries were disposed off near these workshops (Abekah, 1993). Lead and cadmium paints are extensively used in auto body spraying shops. Leaded fuels are also deposited by vehicles that visit the garages for maintenance and repair. Used and waste fuel and oils are also disposed of by the artisans and craftsmen in this maintenance and repair business. It is therefore of no doubt that high concentrations of lead also find their way into water, algae and tilapia fish-muscle in the lagoon.

It has been recorded that higher concentrations of lead and cadmium were in blackchin tilapia muscle in the Fosu lagoon (Obodai et al, 2011). Lead– and cadmium– contaminated tilapiafish–muscle when consumed could have long term health effects.

2.2 Health effects of cadmium intake

A considerable amount of cadmium intake by humans is ingested through the consumption of terrestrial and aquatic biota that feed on plants and animals. It is also well known that plants do absorb cadmium with the same biological set up as animals. However, humans by consuming these plants indirectlythrough animals such as fish also become affected with cadmium build-up (Bernard &Lauwerys, 1997).

Various biological and chemical effects of cadmium in humans have been identified (De Cort, 2000). For example, cadmium ingestion can give rise to salivation, chocking attacks, persistent vomiting, abdominal pains, spasms of the anus, and loss of consciousness. Though cadmium ingestion can be eliminated later, a greater fraction is trapped in body organs. The excess cadmium is stored progressively with time, displacing zinc in an important enzymatic site consequently generating series of disorders in metabolic activities (UNEP, 2010; De Cort, 2000; Merian, 2000; Bernard &Lauwerys, 1997; Kazantzis, 1987; Bernard &Lauwerys, 1986; Kjellstrom, 1986; Marshal, 1978).

In Japan, the effects of long-term heavy metal occupational exposures of cadmium on bones have been identified (Kido, Nogawa, Honda, Tsuritany, Ishizaki,&Yamada, 1987). Cadmium can thus affect bone directly by its effects on calcium and vitamin D metabolism. This may cause painful, softening and bending of bone organs (Kido, Nogawa, Honda, Tsuritani, Ishizaki& Yamada, 1990).

Though cadmium in aquatic ecosystem can gather in mussels, oysters, shrimps, lobsters and fish, the susceptibility to cadmium can change to a large degree between these aquatic organisms(Lenntech, 2008). These organisms when consumed may therefore cause diseases to humans such as chronic painful bones, infertility, and wrist drop among others, and therefore may be an indication of cadmium presence in the human body (Kjellstrom, 1986).

2.3 Health effects of Lead intake

Lead, as a non-essential heavy metal, has no important role to play in the human body. It imitates other biologically essential metals such as iron and zinc. It tends to inhibit enzymes' capacity to catalyze the necessary enzymatic reactions (Kosnett, 2006; Hurlbut& Boyer-Hassen, 2004; Pearson &Schonfield, 2003).

Lead poisoning, depending on the extent and duration to exposure, can give rise to various signs and symptoms. Such symptoms include impotence, infertility and other reproductive disorders. Research has indicated that lead can cause permanent reduction in cognitive (intelligence) abilities in children. The peripheral and central nervous system may also be affected. The commonest symptom of peripheral neuropathy resulting from chronic lead exposure is the weakness of the exterior muscle of the hand (wrist drop). This disorder occurs after several weeks of lead exposure (Bellinger, 2008; Patrick, 2006; Landrigan, Schachter, Lipton, Fahs& Schwartz, 2002). Generally, lead toxicity can lead to the formation of a bluish line along the gums commonly referred to as Burton Line or lead line (William, Berger &Elston, 2005).

2.4 Perception of fishermen on health implications

Perception is the way people think about or understand a phenomenon using the senses. It is the awareness of these phenomena in the environment using the sensory organs. People react towards such phenomena according to the way they perceive them. Generally, perception includes senses, feelings, ideas, thoughts, theories and experiences finally leading to concepts formed by the individual in order to understand differences (Romanov, 2013). Perception can be positive, negative or neutral. It is a process by which sensory experiences are organized and are made meaningful to the one perceiving (Lindgren, Byrne &Lindgren 1971). In other words, perception is an active process by which environmental knowledge is developed and choices made (Fridgen, 1991; Mebratu, 1998).Perception may be defined as the organization, identification and interpretation of information received by the senses so that the environmentcanboth generally and specifically be represented and understoodat the same time (Schachter, 2011). Though perception is based on partially incomplete unproved and unverifiable information received by the senses, it is exacted to true and actual life situations.

Perceptions of the fishermen were therefore determined by asking about lagoon pollution and consumption rate of tilapia. This was followed by questions as to whether eating tilapia from the lagoon could cause infertility, cancer, painful bones, Burton line, painful bones, weakness of the wrist and cognitive deficient children.

3.Research Methodology

Anestimated population of 131fishermen was targeted for the study, based on the pilot study.However 62 were identified to be ready to participate in the study with a response rate of 97%.A questionnaire was employed in gathering data. On few occasions the observational tool was used, particularly in the identification of Burton line.The snowball and purposive sampling methods were employed with open and closed ended questions to collect data.The descriptive method of analysis was used.

4.Results and discussion

The socio demographic parameters of fishermen considered in the study include gender, age, highest educational attainment, and family size. All the respondents to the schedule were male (figure 2); giving an indication that fishing in the lagoon is a predominantly male preserve. According to the fishermen who responded to the schedule, the current average fishermen population was 131. For those who responded (60), all practiced fishing as the primary occupation.

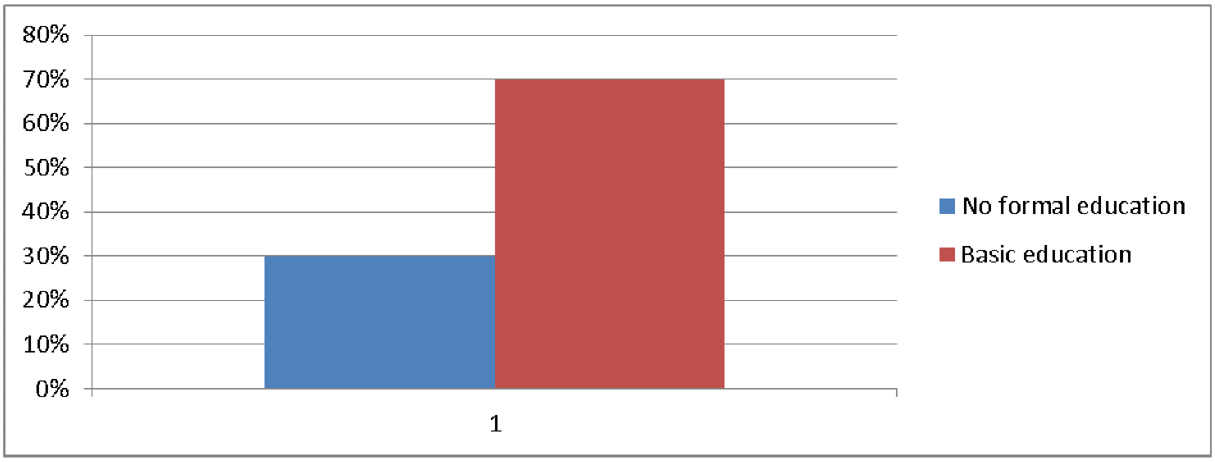

Figure 2: Highest educational attainment of fishermen (Source: Field data, 2012)

The age range was between 30 and 59 years with a mean and modal age of 43 and 41.9 years respectively (refer figure 3). Figure 4 shows the distribution of highest educational attainment of the respondents. Thirty percent of the fishermen had no formal educational background with the highest being basic education; i.e. 70 percent. Over 96 percent had more than one child. The average family size was five children per fisherman (table 1).

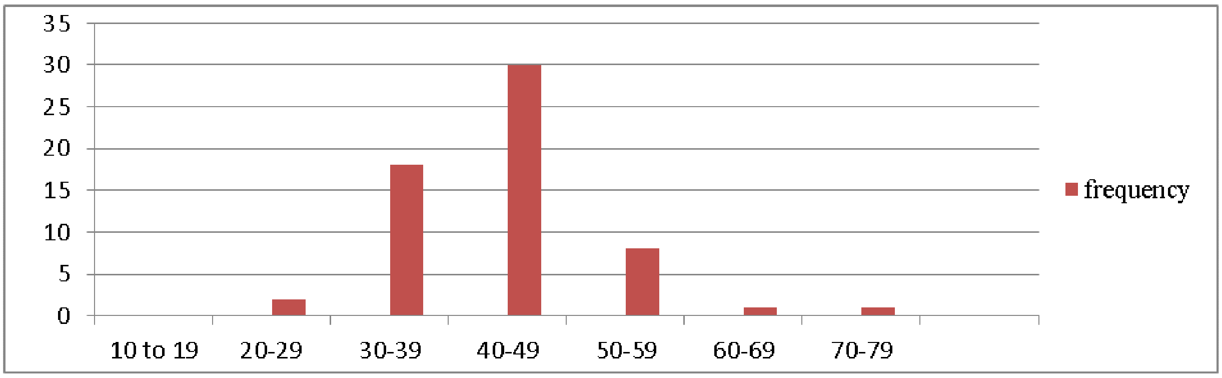

Figure 3: Age distribution of fishermen in years (Source: Field data, 2012)

Table 1: Family size distribution of fishermen (Source: Field data, 2012)

Family size (number of children)	Frequency	percent
1 to 3	8	13.333
4 to 6	34	56.667
7 to 9	18	30
Total	60	100

Figure 4 is a summary of tilapia consumption pattern of Fosu lagoon fishermen. The study found that over 90 percent of the fishermen consumed more than 15.6g – 71.44g of tilapia by weight per meal; an average of 43.52g/meal The remaining (6.7%) consumed between 9.75g and 44.65g; an average of 27.2g/meal or between 12 and 54 fingerlings of tilapia per meal (Obodai, Okyere, Boamponsem, Aheto&Senu, 2011). Thus more than 90 percent of the subjects consumed between 78g and 500g of tilapia per week and that tilapia was the singular largest source of protein for the fishermen. The consumption level of 80% of the fishermen who fish in Barnegat Bay, New Jersey, therefore falls within the consumption rate ofFosu lagoon fishermen (Burger, Sanchez &Gochfield, 1998)

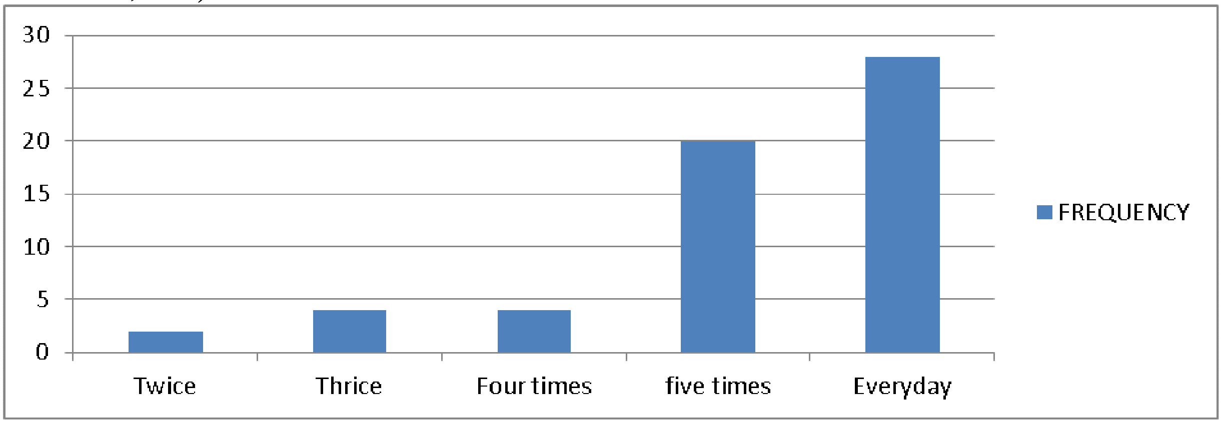

Figure 4: Tilapia consumption rate among Fosu lagoon fishermen (in number of times per week(Source: Field data, 2012)

The study further revealed that majority of the respondents, constituting 60 percent, did not perceived that the lagoon was polluted with lead and cadmium though 46% of this number confirmed that they had on one occasion or the other found scrap metals in the lagoon. The study also revealed that 93.3 percent of the fishermen did not believe that tilapia caught from the lagoon, in general, could cause diseases in spite of the fact that various waste materials found their way into it; though perception levels changed when it came to specific diseases (refer figure 4). Only 4 percent agreed to the contrary. In comparison with Barnegat Bay, New Jersey fishermen (anglers), 90% believed that fish caught were safe to consume (Burger et. al., 1998).

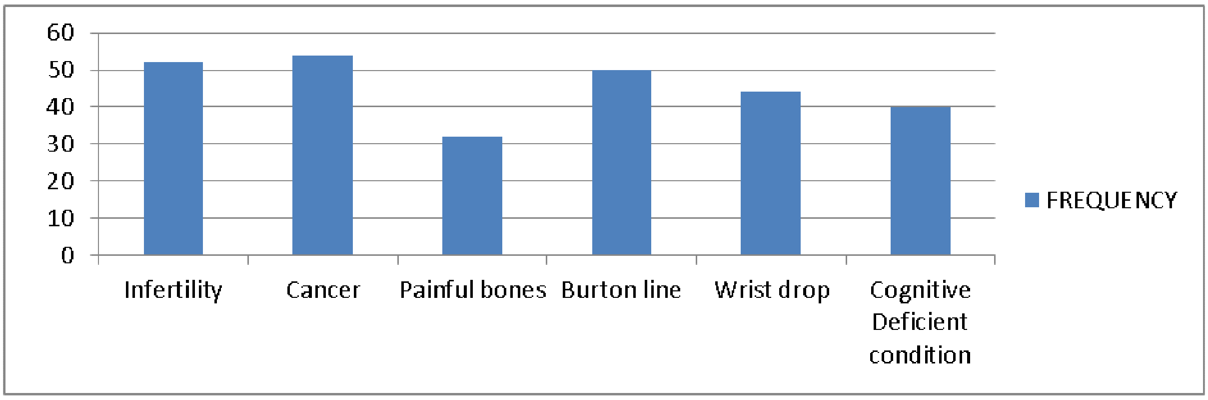

Figure 4: Negative perception on health implications (Source: Field data, 2012)

Over 86 percent of the fishermen were of the view that eating tilapia from the lagoon could not result in infertility in men (refer figure 4) since none of them was infertile. Majority (51.7 percent) of this number thought that infertility had nothing to do with fish consumption.

The study also showed that 90 percent of the fishermen perceived that there was no relationship between tilapia consumption and cancer infections (refer figure 4). On the other hand, 73 percent disagreed that eating tilapia had something to do with painful bones. Seventeen percent disagreed that tilapia consumption could result in Burton line condition while 66.7 percent perceived that tilapia consumption could not result in wrist drop. In terms of cognitive – deficient condition majority of the fishermen (76.6 percent) were of the view that eating tilapia could not lead to cognitive – deficient children (refer figure 4).

Thus Fosu lagoon fishermen had low perception when it came to their risk perception of the fish they caught from the aquatic environment (Burger et.al. 1998). The basis for this perception may be attributed to cultural experience, lack of knowledge and cognition (Darkwah&Smardon, 2010). Low level of education could be a factor for low risk perception in this regard. The high fertility rate among the fishermen and absence of serious negative medical conditions may also lead to low risk perception, among the fishermen. Occasional use of herbs among majority of fishermen, as traditional cultural practice even when there is no sickness or disease, may contribute to absence of prevalent negative health conditions. The absence of prevalent negative health conditions could consequently lead to low risk perception among the fishermen.

5.Conclusion and recommendations

The findings from the study indicate that all the fishermen who fished in the Fosu Lagoon consumed tilapia caught fromthe lagoon and that tilapia was a major source of food and protein. This consumption rate is high enough to negatively affect the health of fishermen. In spite of lead and cadmium pollution of the lagoon and fish muscle, fishermen perceived that eating tilapia from the lagoon could not have negative implications on their health.

In view of the conclusions of the study it is recommended that risk communication strategies that involve health officers in general and doctors in particular should be used to promote public health among the general public in general and fishermen in particular. In a concerted and holistic approach the Metropolitan Health Directorate and Metropolitan Assembly, the Environmental protection Agency (EPA) and Non-governmental organizations (NGOs) such as Greenstar Foundation in Cape Coast should take the task in educating fishermen to acknowledge and appreciate the food-chain dimensions of public health; that consuming fish from a polluted environment could have negative health consequences. Radio as a medium of communication should be used in this exercise. It is further recommended that education, using the vernacular, should aim at fishermen appreciating the possible effect of their activities and its negative health implications on people who depend on tilapia from the lagoon as food as well as on the lagoon for their livelihood and sustenance.

References

Abban, E. K., Asante, K. A. and Falk, T. M. (2000) Environment of blackchin tilapia, Saratherodonmelanotheron, and their potential effects on the genetic structure of stocks in Ghana, p 14-16. In E. K. Abban C. M. V. Casal, T.B. M. Falk and R.S.V.B.Pullin (Eds.) *Biochemistry and sustainable use of fish in the coastal zone.* ICIARM Conf. Proc. Pg.63-71

Abekah, S. F. (1993) *A case study of Siwdo garages (Cape Coast) and its surroundings*. Unpublished Dissertation, Department of Geography, University of Cape Coast, Cape Coast.

Adjei, C.A. (1991) *Determination of copper and zinc levels in the sediments of the Fosu lagoon Cape Coast*, University of Cape Coast, Cape Coast.

Ahuahey, C.Y. (2007) *The effects of Siwdo workshops and its surroundings on the Fosu lagoon in Cape Coast.* A project report submitted to the Mechanical Engineering Department of Cape Coast Polytechnic, Ghana.

Akwansah-Gilbert, E. (2007) *Distribution of Polycyclic aromatic hydrocarbons and heavy metals in the Fosu lagoon of Cape Coast Ghana*. Thesis submitted to the Department of chemistry. University of Cape Coast.Cape Coast.

Berlinger, D. C. (2008) Very low lead exposures and children neurodevelopment.*Current opinion in pediatrics* 20(2) 172-7

Bernard, A.M., and Lauwerys, R.R. (1986) *Effects of cadmium explosive in humans: Handbook of experimental pharmacology*. E.C. Foulkes, (Ed) Berlin: Springer's – Verlag. P 135-177.

Blay, Jnr, A. and Asabere- Ameyaw, J. (2007) Assessment of the fisheries of a stunted population of the cichlid sarotherodonmelanotheron (Rappel) in a "closed" lagoon in Ghana. *Journal of Applied Ichthyology*.Vol 4, Issue 1, jpp1-11

Burger, J. and Gochfield, M.(1998) Fishing, consumption and risk perception in fisher folk along an East Coast estuary.*Environmental research*, Vol. 77, Issue1, pp 25-35.

Cunningham, W. P. and Saigo, B.W. (1997) *Environmental Science - A Global Concern*, McGraw-HillInc, pp 272,422,425.

Dadson, F.A. (1996) *Analysis of micro-pollutants in lagoon fish muscle*, University of Cape Coast, Cape Coast.

Darkwah, S., and Smardon, R. (2010) Ecosystem restoration: evaluating local knowledge and management systems of fishermen in the Fosu lagoon, *Environmental practice*, Vol 12, Issue 03, pp 202-213. http://dx.doi.org/10.1017/s1466046610000256. 14/04/14

De Cort, F. (2000) *Environmental Chemistry*.4th Edition.New Age International Ltd Publishers, New Delhi Health, vol.2, pp 21-09.

Doe, N.G.(2007) *Levels of mercury and cadmium in selected biology species from Pra River- a study of pollution of the river Pra estuary*, M. Phil Thesis submitted to the University ofCape Coast.

Essumang,D. K., Dodoo, D.K. and Kendie, S.B. (2006) The effects of leachates from solid waste disposal site on the Cape Coast municipality Environment, *Ghana Journal of Chemistry*, 7(1), pp 20-26.

Fridgen, J (1991). Dimensions of tourism. East Lansing, MJ: *American Hotel and Motel Association Educational Institute*.

Hagan, S (1986) *Determination of the levels of pollution of trace heavy metals in cape coast Fosu lagoon*, University of Cape Coast, Cape Coast, Ghana.

Kendie, S. B. (1999) *Do attitudes matter? Waste disposal and wetland degradation in the Cape Coast municipality of Ghana*, Development Planning Center, University of Bradford (Discussion Paper Series 2) No. 21, pp1-9.

Kido,T., Nogawa, K., Honda, R.,Tsuritani, I.,Ishizaki, M.,and Yamada, Y. (1990) The association between renal dysfunction and osteopenia in environmental cadmium-exposed subjects,*Environmental Research* 51:71-82

Kido,T., Nogawa, K., Honda, R., Tsuritani, I., Ishizaki, M., and Yamada, Y. (1989) Osteopenia in Inhabitants with Renal dysfunction induced by exposure to environmental cadmium, *Int. Arch. Occ Environ. Health* 61; 271-276.

Kjellstron, T. (1986) Effects on bone: vitamin D and calcium metabolism, *Int. cadmium and Health*, vol. 2, pp 111-157.

Kosnett, M. J.(2006) "lead" in Olson, K.R. *Poisoning and dry overdose*, ed. McGraw- Hill professionals p:238

Landrigan, P. J., Schachter, C. B., Lipton, J. M., Fahs, M. C., and Schwartz, J. (2002) Environmental pollutants and disease in American children, *Environmental health perspectives* 110(7):721-8 PMC1240919.PMID12117650. 04/12/12

Lentech (2008) *Water treatment and air purification*.Holding B.V., Rotterdamseiveg 402m 2629 HH Delft, the Netherlands.

Lindgren, H. C., Byrne, D. and Lindgren F., (Eds.) (1971) *Current Research in Psychology: A book of Readings*. New York: Wiley, Pp 119,159-160.

Marshall, R. (1978) Occupational Safety and Health Administration (OSHA), General Industry,*OSHA Safety and Health Standards*, 29 CFR 1910 OSHA.

Mebratu D. (1998) Sustainability and Sustainable development: Historical and Conceptual Review,*Environment Impact Assessment Review* (18) 493-520.

Mensah, J. V. (1997) *Causes and effects of coastal sand mining in Ghana, Centre for Development studies,* University of Cape Coast, Ghana, Singapore journal of Tropical geography, 18 (1), 1997, 69-88.

Merian, E. (2000) Environmental chemistry and biological effects of cadmium components, *Toxicological and Environmental chemistry*, Vol 26. Issue 1-4,pp 27-44

Mohammed, H. (1993) *Lagoon pollution: A case study of Fosu lagoon*, University of Cape Coast, Cape Coast, Ghana.

Obodai, E. A., Okyere, I., Boamponsem, L. K., Mireku, K. K., Aheto, D. W., and Senu, J. K. (2011) Comparative study of tilapine populations from two contrasting habitats of Ghana, *Der ChemicaSinica*. 2(5):200-210

Patrick, L. (2006) lead toxicity, review of the literature. Part 1: Exposure, evaluation and treatment. Alternative medicinal review.*Journal of clinical therapeutic* 11(1) 2-22 PMID 16597190 04/12/12

Pearce, J.M.(2007) Burton's line in lead poisoning.*European Neurology* 57 (2) 118-9 doi: 10.1159/00098100 PMID 171719 04/12/12.

Pearson, H. A. and Schonfield, D. C. (2003) Lead,In Rudolph C.D, *Rudolph's pediatrics*, 21st ed. McGraw-hill professional, p 369.

Romanov, N. (2013) *What is perception*? Jelsoft Enterprise Ltd. Version 3.6.8.

Schacter, D. (2011) Psychology. Worth publishers.

Sinha, S.,Shukla, M. and Shukla, R. (2005) *A text book of Environmental Studies*, AITBS Publishers, and pp 170-174.

Tay, C.A. (1989) *Preliminary studies on the levels of inorganic pollution in Fosu lagoon (Cape Coast)* B.Sc. lab.Tech, Dissertation.University of Cape Coast, Cape Coast.

Toth, T., Andreji, J., Toth, J., Slavic, M., Arvay, J. and Stanovic, R. (2012) Cadmium, lead and mercury contents in fishes –case study, *Journal of microbiology, biotechnology, and food sciences*, 1: (February special issue) 837-847.

Trevor, A.J., Katzung, B. J. and Basters, S. B. (ed) (2007) Heavy metals: Katzung& Trevor's pharmacology. *Examination Board review* (8th Ed) McGraw Hill Professional.

Tripathy, S. N. and Panda, S. (2003) *Fundamentals of environmental studies*. Vrinda Publications (P) Ltd. Pp 98, 99.

UNEP (2010) United Nations Environment Programme, Chemicals branch, PIITE, *Final Review of scientific information of Cadmium*, pp 40-50.

Utz, J. (2000) What percentage of the human body is composed of water? Madsci Network: Anatomy. Webadmin @ www.Madsci.Or. 16/02/11.

William, J., Berger, T. and Elston, E. (2005) Andrew's Disease of the Skin, *Clinical Dermatology*, (10thed), Saunders.

Author

- Ing. Emmanuel Baffour-Awuah, (MGhIE). This author became a Member of the Ghana Institution of Engineers in March 2010 and a Senior Member in November 2010.
- Date and place of birth: 28th August, 1967; Tarkwa, Western Region, Ghana, West Africa.
- Degrees:**1**. B. Sc. (Hons) Agricultural Engineering; Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; 1993. **2**. Post Graduate Diploma in Education; University of Cape Coast, Cape Coast, Ghana; 1998. **3**. M. A. (Environmental Management and Policy); University of Cape Coast, Cape Coast, Ghana; 2012.

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