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Sewage Fish Culture as an Alternative to Address the Conflict between Hunters and Hunting Communities in Northern Region

Mr. Issahaku Abdul-Rahaman (Corresponding author)
Center for Continuing Education and Interdisciplinary Research (CCEIR), University for Development Studies (UDS), Navrongo Campus, P. O BOX 24, Navrongo, Upper East Region, Ghana
Dr. Mark Owusu-Frimpong
Department of Biology, University for Development Studies (UDS), Navrongo Campus, P. O BOX 24, Navrongo, Upper East Region, Ghana
Prof. Patrick K. Ofori-Danson
ECOLAB, University of Ghana, Legon

Abstract

The people of Tamale in the Northern region of Ghana also hunt as a recreational or traditional or hobby at weekends during the dry season. Wild animals are indiscriminately killed and this poses a threat to the wildlife populations in the country. The conflict between hunters and hunting communities, the dangers involved in communal hunting, the occasional loss of lives, the destruction of the plant cover and the burning of farms is an indication that an alternative is necessary. Sewage fish culture is one of such alternatives. Human faeces are an effective fattening diet for fish. Sewage-fed ponds contain high levels of N, P, Ca, and K (Pacey, 1978) and can produce as high as 7-10 t/ha/yr of fish (FAO, 1994) depending on the sewage retention time (Kalbermatten et al., 1982). The use of sewage for fish culture has the potential to defray the costs of sanitation and sewage treatment processes in Tamale and other towns and cities in Ghana.

Introduction

Many people in Ghana as in other African countries depend on bush meat as a source of animal protein (Martin, 1983). Bush meat is also preferred in traditional chop bars and has become expensive in recent times. Bush meat may be a source of income for some people in Ghana (Ntiamoa-Baidu, 1987). The people of Tamale in the Northern region of Ghana also hunt as a recreational or traditional or hobby at weekends during the dry season. Both commercial and recreational hunters use guns, trapping, snaring, simple tools and dogs for hunting (Asibey, 1978) and sometimes fire. Hunters enter the bush to seek and kill desirable wild animals either for domestic consumption or for sale. Wild animals are indiscriminately killed and this poses a threat to the wildlife populations in the country. The conflict between hunters and hunting communities, the dangers involved in communal hunting, the ocassional loss of lives, the destruction of the plant cover and the burning of farms is an indication that an alternative is necessary. Sewage fish culture is one of such alternatives.

Human faeces are an effective fattening diet for fish. Sewage-fed ponds contain high levels of N, P, Ca, and K (Pacey, 1978) and can produce as high as 7-10 t/ha/yr of fish (FAO, 1994) depending on the sewage retention time (Kalbermatten *et al.*, 1982). Sewage may be converted into income (Meadows, 1983) and high quality protein through fish culture. Sewage reuse is a preferred method of sewage disposal to minimize treatment costs and obtain maximum agricultural and fish culture benefits from the residual nutrients in the sewage (WHO, 1989a). Fish production in sewage-fed ponds is a common practice around the world, especially in Asia (Khalil and Hussein, 1997). In China, about two-thirds of all farmed fish, is obtained from ponds fertilized with excreta. In India, particularly in West Bengal (Dehadrai and Ghosh, 1977) sewage is reused for fish culture. In Indonesia, fertilization of fishponds with excreta is practiced mainly in the Southwestern Java province (WHO, 1989b) where 33 000 tonnes of the Nile tilapia (*Oreochromis niloticus*) were produced in 10,000 ha of ponds annually. In Thailand, almost 20 percent of the annual per capita consumption of 22.9 kg fish is produced from sewage-fed ponds (Josupeit, 1981). In recent years interest in the reuse of excreta for fish culture has spread to other parts of the world (Edwards, 1985). In the developed world, sewage fish culture has been reported in Europe including Poland and Germany (Bailly 1979). About 60% of the total fishpond production in Czechoslovakia comes from sewage-fed ponds (FAO, 1992). Sewage fish culture has also been reported in North America (Colman and Edwards, 1987).

Environmental factors in sewage ponds that affect survival and growth of fish may be physico-chemical or biological and they include water temperature, dissolved oxygen, pH, carbon dioxide, ammonia, nitrites, nitrates, turbidity, nutrients and food organisms (Zhou, 1986). Every fish species has a preferred range for each of the environmental parameters (Boyd, 1990). To achieve fast growth and efficient performance the ponds should have optimal levels of these environmental parameters (Colt and Armstrong, 1981).

The use of sewage for fish culture has the potential to defray the costs of sanitation and sewage treatment processes in Tamale and other towns and cities in Ghana. In the light of this Ghosh (1983) proposed sewage fisheries or sewage fish culture development as an economically feasible means of decreasing river pollution. However, excreta reuse is not traditional in many societies, and there may be deep cultural prejudice or taboos concerning the consumption of fish raised on human excreta (Cross, 1985).

1.1 Problem Statement

People in Tamale like in other developing countries may be malnourished due to low intake of animal protein. Increased population density and indiscriminate exploitation of wild animals are depleting wildlife rapidly in most places in Northern Ghana. Indiscriminate hunting of wildlife using fire, guns and chemicals have resulted in degraded ecosystems, loss in biodiversity, and pollution of water bodies meant for rural dwellers, burning of farms and food stuff and loss of lives. Alternative source of protein and the enforcement of the law on communal hunting are required to curb the conflict between hunters and hunting communities.

1.2 Objectives

The main purpose of the study was to gather information on communal hunting in Tamale by studying the communal hunting activities of inhabitants of the metropolis. The specific objectives are:

To determine the causes of conflict between hunters and hunting communities
To assess the acceptability of sewage cultured fish as one of the alternatives for communal hunting.
To assess the bacteriological and physicochemical suitability of sewage treatment ponds for fish culture

Study Area and Methodology

The study area covers Tamale, West Gonja, East Gonja, Tolon/Kumbungu, Savelugu/Nanton, and Yendi Districts where hunters from Tamale usually go to hunt. A purposeful sampling procedure was followed among hunters from Tamale to solicit their views about communal hunting. Focal group discussions were held with chiefs and opinion leaders of hunting communities to ascertain the perception of the people about the effect of communal hunting on the environment and communities.

Fish was cultured in hapas of 1m^3 volume and immersed 75cm deep into the water. The immersing of the hapas was aided by tying waste at the four bottom corners of the hapas. Water sampling was done at each of the treatment ponds at Gbalahi, a suburb of Tamale to ascertain its suitability for fish culture.

Plate A: A specimen hapa being shown in a pond

The discharged pond, the control pond, the primary facultative, the secondary facultative and the aerobic ponds were numbered 1, 2, 3, 4 and 5 respectively. Two tilapia species (8-9 g each) commonly cultured in Ghana, namely *Oreochromis niloticus* (Linnaeus) and *Sarotherodon galilaeus* (Steindachner) were cultured in hapas (Plate A) at the sewage treatment ponds in Tamale. Length and weight of the cultured fish were measured at stocking and every two other weeks for a period of six months.

Both pond temperature and pH were measured three times at different locations directly from a boat (Plate B) with a thermometer and a digital pH Meter (Model CG818) respectively at a depth of 20 cm. Depth measurements were also taken from a boat in the upper, middle and lower portions of the ponds using a rope tied to a weight. Physicochemical and bacterial load were measured using standard methods (APHA, AWWA, WEF, 1998) at the water research institute in Tamale.

Plate B: Depth measured been taken in a pond

Un-ionised ammonia (NH_3) was calculated by multiplying conversion factor and ionized ammonia ($NH4^+$) values obtained from ponds (Ruth and Craig, 2005). Conductivity meter (Model CMD 200) was used to determine conductivity (Eaton *et al.*, 1995) from three portions of the same sample.

Estimation of fish potential yield was done using a relation 8.7489MEI0.3813 provided by Henderson and Welcomme (1974), Where MEI is the morphoedaphic index of each pond.

A sample of 1000 people were interviewed to find their interest or otherwise of sewage cultured fish from public places, schools, homes and individuals on the street. SPSS and Microsoft Excel was used to analyze the perception of the people about sewage fish culture.

Results and Discussion

Causes of Conflict between Hunters and Hunting Communities

The respondents were predominantly farmers who hunted for meat or for income. Government employers, drivers and mechanics also took part in the hunting expeditions. The number of hunters per each hunting expedition was 200-400. Two types of communal hunting were identified namely, day group hunting and night group hunting. Equipment used for hunting included guns, chemicals, clubs, cudgels, knives and the " za-ani" (a locally manufactured tool). Dogs were used to run down and kill the animals. Fire was occasionally used at bushy places to expose the dwellings of animals. Larger number of people went on the hunting expeditions because they had greater interest and this occurred mostly in the dry season. The "Mogori Kpema," the leader of the hunting group is responsible for organizing transportation usually articulator trucks to carry hunters for the expeditions. He is also their spiritual leader and prays for safe hunting and successful hunting. A drummer beat a drum early in the morning to alert hunters that there will be hunting expedition. He also beat the drum in the field to stimulate hunters, give direction and flushed out animals such as rodents from their hide out. The hunting days are mostly on Saturdays, Sundays and Wednesdays. None of the hunters hunted for all the three days in a week due to lack of transportation fares. The fare for a hunting expedition is about GH¢2-3 and it was not certain that each hunter would get a catch on each hunting day. Hunters could travel between 80-120 km to reach hunting site.

Hunters or members of hunting communities may be surrounded by bush fires during a hunting expedition leading to death for suffocation. Lives may also be lost due to overloading of vehicles. Sometimes a whole community could be burnt down as a result of fire set by hunters. The Nanton chief and the acting Northern regional NDC chairman lost several acres of rice fields to fire in the year 2010 (GTV News, 2010). Fire may also destroy food meant for wildlife thereby breaking the food chain. As a result some animal species may be extinct and some may even migrate into other reserves affecting tourism potential of the area. It was the opinion that yearly exposure of economic trees such as shea tree (*Vitellariaparadoxa*) and dawadawa tree (*Parkiabiglobosa*) may lead to low yields and deprive those who depend on them their livelihoods.

Physico-chemical Parameters of Sewage

A propose site for such activity is Gbalahi sewage ponds. The temperature of a water body is affected by the season among other factors (Chapman, 1992) and the mean temperature of the Gbalahi fish ponds reflect the cool temperatures of the Northern Ghana Savanna Hamattan Season, ranging from 17^0C in January to 29^0C in November. The optimal temperature for tilapia (*O. niloticus* and *S. galilaeus*) is 20^0 to 30^0C and they cannot tolerate temperatures outside the 15^0C-37^0C range (Wohlfarth and Hulata, 1983). The temperatures of the Gbalahi sewage ponds are therefore appropriate for fish culture. Sewage ponds are usually warmer than natural waters due to oxidation of organic substrates that occurs within them and therefore ameliorate the effects of cool seasons like the hammattan (Edward and Pullin, 1990).

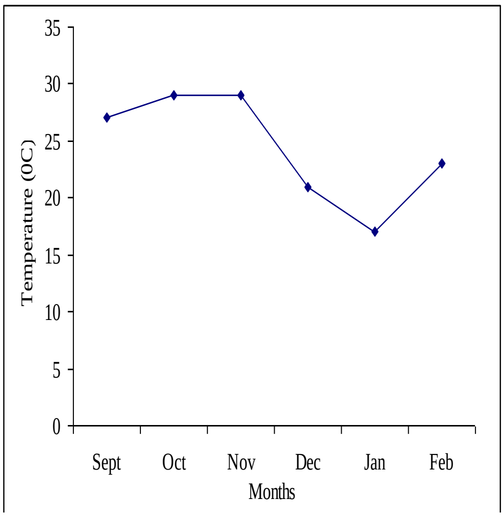

Fig 2. Temperature values of the treatment ponds

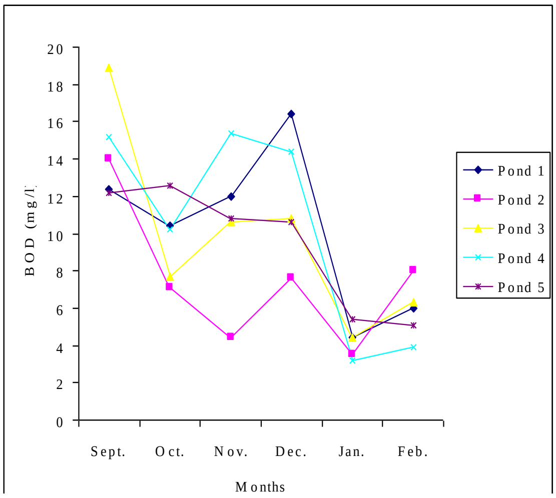

Fig 3. BOD values of the treatment ponds

BOD (Fig 3) varied seasonally. Low BOD (<8.0 mg l-1) occurred in January while high BOD (> 12.0 mg l-1) occurred in September. Sewage truck drivers often sell sewage to farmers to fertilize their crops but the heavy September rainfall precludes this practice leading to a higher discharge of sewage into treatment ponds resulting into oxygen depletion due to bacteria digestion of sewage substrate. Wastewater normally has BOD values up to 10mg/l or more (EIFAC, 1973) and a high BOD indicates oxygen depletion (Carla, 1992).

The aerobic pond (Pond 5) had an average BOD of less than 10mg/l and so the pond was suitable for fish culture. The discharge pond (pond 1) could not support fish culture because of high BOD as seen in Fig 3. The control pond (Pond 2) was equally not suitable for fish culture because organic matter from the solid waste dump side was connected to the pond and led to high BOD due to bacterial activity. The combined BOD load of the discharge and the control ponds which was discharged into the primary pond (Pond 3) and secondary pond (Pond 4) led to an increase in BOD in both ponds.

The water in the treatment ponds was basic pH>7 and indicated the presence of sodium and potassium ions in concentration. Differences in pH were observed between ponds. The pH was generally high (8.0-10.3) in all the ponds: the mean pH for ponds 1, 2, 3, 4 and 5 was respectfully 9.4, 8.5, 9.7, 9.6 and 9.7. High pH is a threat to fish life because it corresponds to high concentrations of toxic ammonia (NH_3) (Klontz, 1993). Low pH upsets oxygen uptake and ion regulation, which can lead to skin degeneration (Shepherd and Romage, 1992).

High concentrations of toxic (un-ionized) ammonia (NH_3) exceeding 2.0 mg/1 occurred at certain times of the study. The lowest (0.05 mg/l) and highest (3.04 mg/1) concentrations were recorded in Pond 2 in December and Pond 5 in January respectively. In general, Pond 2 showed the lowest overall mean monthly concentration (0.95 mg/1), while Pond 5 showed the highest (2.15 mg/1) (Table 1). Alabaster and Lloyd (1980) have noted that ammonia toxicity increases with rise in both pH and temperature. The pH values obtained during the study were above the upper limit of 9.0 set by the EPA (1998) and tilted towards alkalinity. Steps must be taken to reduce the level of pH in the ponds through regular dilution with fresh water for sustainable production of fish. Dissolved oxygen (DO) vary significantly from pond to pond. Mean DO remained high (5.9-7.6 mg/1) in all the ponds throughout the study. The lowest DO (3.3 mg/l) was recorded in Pond 2 and the highest (10.1 mg/1) was recorded in Pond 4.This implied that there was enough oxygen for fish growth in pond 4. Dissolved oxygen levels help to determine how polluted a water body is as a result of contamination by organic substances. A low level of dissolved oxygen in water indicates the presence of excessive amounts of organic matter (Atlas, 1995 and Zweig *et al.*, 1999). Fish culture production can be limited by the availability of oxygen Rosenthal, 1988. Fish growth and survival require dissolved oxygen (Boyd, 1990) at a concentration between 4 mg/l and 14 mg/l (Meade, 1989) however; some fish can survive at DO levels as low as 1.0 mg/l at a slow growth rate (Boyd, 1984). Generally, DO during the study exceeded 5mg/l set by EPA (1998) and implied that the ponds were suitable for the culture of fish. The higher the DO the higher the growth rate and fish survival.

Table 1. Monthly un-ionized ammonia (NH3) concentrations (mg/1) in the treatment ponds

Un-ionized ammonia (NH_3) concentration (mg/l)					
Months	Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
Sept.	1.78	1.25	1.27	0.91	0.54
Oct.	1.52	2.94	0.78	1.77	1.91
Nov.	2.53	0.1	1.8	2.07	2.87
Dec.	0.68	0.05	2.15	1.35	1.77
Jan.	0.71	0.47	2.16	2.02	3.04
Feb.	1.49	0.91	1.97	1.92	2.75

(Fig 4) increased steadily throughout the study. The average conductivity was 1128 µS/cm in the ponds. Michaud (1991) has indicated that, an increase in the discharge of sewage increased conductivity due to the presence of chlorides from kitchen waste. The high conductivity implied that the ponds may be rich in nutrients and suitable for fish culture.

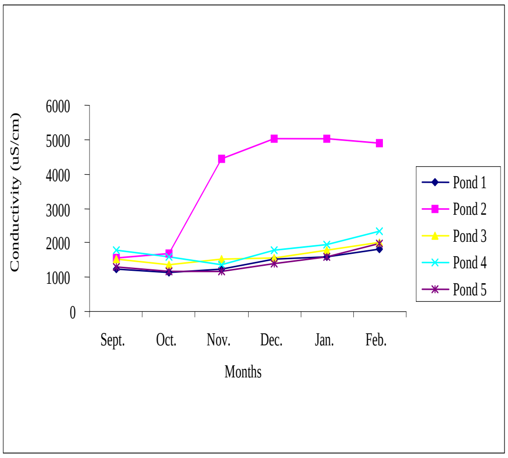

Fig 4. Conductivity of the treatment ponds

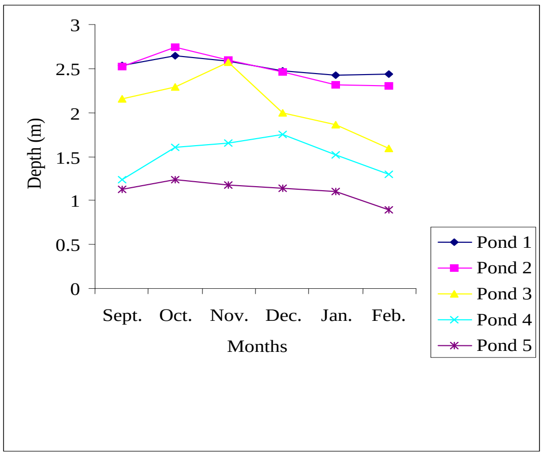

Fig 5.Water depth of the treatment ponds

The depth of water (Fig 5) in ponds averaged 1.1 to 2.5 m in the course of the study. Fish growth and survival may be better in ponds with a depth of at least 60cm as observed in the study. A lower depth resulted in the depth of fish. More water was used and discharged during rainy season than the dry season. As was discovered by Ruangrit *et al.,* (2005) more sewage is generated in rainy season because of higher water availability. Waste water could have also been recycled during the dry season thereby reducing the volume of water in the dry season. A shallow water depth was stressful to fish and led to death. Hapas must therefore be adjusted periodically to avoid stress. Water levels in the ponds were adequate for fish culture.

3.3. Potential Yield of Fish in Sewage

Potential yield can be increased by lowering the depth of fish ponds and maintaining or increasing the conductivity in the ponds (Table 2). Compared to Ofori-Danson,s (1999) mean estimation of 15.55 kg/ha/yr for the Volta Lake, the potential yield of fish was between 197kg/ha/yr and 269 kg/ha/yr in sewage ponds and indicated that sewage ponds are suitable for the culture of at least *O. niloticus* and *S. galilaeus.*

Table 2. Estimated potential fish yield in the ponds based on MEI values.

Pond	Months	Mean water depth (cm)	Conductivity (μS/cm)	MEI	Potentialyield(kg/ha/yr)
1	6	2.5	1434	574	197
2	6	2.5	3783	1513	285
3	6	2.1	1629	776	221
4	6	1.5	1797	1198	261
5	6	1.1	1429	1299	269

In summary, the depth of water in the ponds (>60cm) was suitable for fish culture and BOD (>10mg/l) recorded in the ponds were not suitable for fish culture. DO (>5mg/l) and conductivity (1429) recorded in the aerobic pond were suitable for fish culture. NH_3 (>2mg/l) recorded in all the ponds was toxic to fish unless waste water was periodically diluted.

3.4. Bacterial Load in Sewage.

The respective mean populations of total coliform bacteria in the five ponds were 5,968; 35,682; 14,782; 9,833 and 5,058 cfu. The differences were significant and revealed that pond 2 might not be suitable for fish culture because the population of total coliforms in pond was so high (35,682). Total coliform bacteria are a principal indicator of the suitability of water for fish culture (APHA, 1995). Pond 1 and Pond 5, however, had similar mean values because pond 1 was the control and pond 5 was the aerobic pond. The populations of faecal coliform ranged from 64-8300 cfu. The population of faecal coliform was higher in the control pond (818 cfu) than in the aerobic pond (274 cfu) because discharge was allowed into the control pond from the solid waste. Chapman (1992) noted that coliform bacteria occur in faeces of humans in large numbers. However, the survival of faecal coliform bacteria outside the intestine may depend on the physical or chemical environment (Jeremy *et al.,* 1995).

3.5 Growth of Cultured Fish in Sewage

O. niloticus and *S. galilaeus* fingerlings were of uniform size (average weight=9.0 g and average total length=7.0 cm) at the time of stocking. After six months of culture in hapas without supplemental feeding the size of *O. niloticus* was between 37.0 g and 45 g, while *S. galilaeus* was between 25 g and 54 g. In general, both species grew at a similar rate in all the ponds, except in Pond 3 where *O. niloticus* grew faster (mean weight=23.7 g) than *S. galilaeus* (mean weight=14.9 g) (Table 3). Ram *et al.*, (1982) have indicated that growth of fish decreased with increased in un-ionised ammonia concentration and suggested that un-ionised ammonia nitrogen is a threat to fish culture. To obtain maximum yield and sustainability of tilapia culture at Gbalahi ponds, un-ionised ammonia nitrogen must be lowered by periodic dilution.

Table 3. Growth of *O. niloticus* and *S. galilaeus* in hapas inside sewage treatment ponds:

	Mean weight (g)		Mean total length (cm)	
Treatment pond	*O. niloticus*	*S. galilaeus*	*O. niloticus*	*S. galilaeus*
Pond 1-Control	16.0	15.8	9.5	9.0
Pond 2-Discharge	10.0	9.5	8.0	7.5
Pond 3-Primary Facultative	23.7	14.9	10.6	8.9
Pond 4-Secondary facultative	20.9	21.1	10.4	9.7
Pond 5-Aerobic	28.4	28.4	12.8	10.4

3.5. Socioeconomic Factors

The respondents were made up of 60% males and 40% females. Coincidentally, the respondents (60%) who indicated that they would accept sewage cultured fish also consume more fish than the 40% who would not eat sewage cultured fish. In general 75% of respondents with high education (senior secondary and above) said they would eat sewage-cultured fish. This is an indication that, sewage cultured fish could be accepted in Tamale. The respondents belonged to different religious faiths. Residents in Tamale are predominantly Moslems (GSS, 1993). Islam and Christianity which emerged as the dominant religions in the metropolis would not reject the consumption of sewage cultured fish because 56% and 36% of respondents respectively indicated they would consume sewage cultured fish.

The implication of this is that, Islam is not against the culture and consumption of sewage cultured fish. Thus the use of sewage for fish culture is socially acceptable (Edwards, 2000). Sewage fish culture in the country should therefore be encouraged by stake holders in charge of food, water and sanitation so that communal hunting will be nib in the back.

Respondents were grouped into the following income brackets, namely high (>¢ 1000.00/month), middle (¢500.00-1000.00 /month), low (< ¢500.00/month) and no income (¢0.00/month). In general the poor and those without income, 56% of whom were students would consume sewage cultured fish.

The outcome of the survey seemed to suggest that the poor would not mind eating sewage-cultured fish: close to 80% of the respondents who said they would accept fish from sewage-fed ponds were in the low income and no income brackets. The use of sewage for fish culture could provide food, income and employment (Will *et al.*, 2005) for some of these people to enable them improve upon their living standards).

The survey identified different sources of animal protein in the diet of the people living in the Tamale metropolis. Mutton, pork, goat and beef but were costly animal protein in Tamale. However fish lovers and beef were the dominating preference.

This confirms that there is a viable market for sewage cultured fish in Tamale. The adoption of sewage cultured fish as an alternative to communal hunting could make protein cheaper for the poor. Educational institutions who might find it difficult to feed students with meat could be provided with a more cost effective alternative by depending on sewage cultured fish. The school feeding program would also be sustained if sewage fish culture is adopted. This demands collaboration with the Ministry of Education, Ministry of Food and Agriculture, Ministry of Water Resources, Works and Housing, Ministry of Environment, private fish traders and private schools.

The respondents expressed various concerns or views about the consumption of fish raised in sewage ponds. As many as 44% of the respondents shared the concern that sewage cultured fish could pose potential health risks to consumers because of the presence of human excreta in the sewage ponds. However, 25% of the respondents were of the view that fish from sewage-fed ponds could be as good as fish from other sources including the wild, reservoirs and conventional ponds. Another positive view was that fish from sewage-fed ponds could be cheaper and has the potential to benefit the poor. Although some respondents in Tamale claimed sewage cultured fish could be harmful, Wim *et al.,* (2005) have reported that human pathogens are found in the guts of fish and not the flesh and that transmission of diseases is through consumption of raw or partially cooked fish. Fish in sewage do not differ from any other fish. Despite health concerns, there is potential for consumption of sewage cultured fish in Tamale especially amongst the poor, students and moslems who predominate in the north of the country more than the south.

Conclusion

People in Tamale hunt for food or cash to maintain their families; however the negative effects of communal hunting are a potential source of conflict. For example farms are burnt, homes are burnt and wildlife is lost as a result of communal hunting. An alternative to communal hunting that will provide the needed protein requirement at a cheaper cost for the family is sewage cultured fish which should be embraced by all for the following reasons:

The physico-chemical parameters (in the sewage ponds measured in this study) were generally suitable for fish culture (compared to information in literature).

Pathogenic bacteria populations in aerobic sewage ponds were lower (<900 cfu) than the acceptable standard (5000 cfu) set by the EPA of Ghana for waste water, which suggests that fish raised in the ponds would not pose health hazards.

Recommendations

Effort should be made to educate the people, as well as enforce the Wildlife Conservation Regulations, (L. I. 1452 of 1989) and (L. I. 685 of 1971).

Since the load of pathogenic bacteria in the ponds was relatively low and generally within acceptable levels (EPA's standards), public education on the safety of sewage-cultured fish is needed to increase consumer acceptance because those who would not eat sewage fish simply assumed that the fish could be contaminated.

Fish should be cooked well and possible contamination through handling and processing should be avoided.

There should be periodic dilution of sewage ponds to reduce ammonia toxicity.

Treatment ponds should be constructed in all cities and towns.

Further research is needed to determine levels of pathogenic bacteria in the muscle of sewage-cultured fish to guarantee consumer safety.

The success of using sewage for culturing fish largely depends on the collaboration of all stake holders.

To maintain the culture of the people communal hunting could be targeted to some wild animals who might be destructive to crop culture.

Trophy hunting as in the case of the Efutu of Winneba in the Central region should also be introduced in Tamale as a form of recreation.

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Tamale Metropolitan Assembly (TAMA), Tamale

Water Research Institute,Center for Scientific and Industrial Research, Tamale

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Department of Fisheries, Ministry of Food and Agriculture (MOFA), Tamale