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Determination Of Sources Of Water Pollution

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ABSTRACT: Water is one of the most important compounds that profoundly influence life. In spite of its enormousness, increasing the population of any country increases the demand for water supply and everything needed by man for survival. Satisfying these anthropogenic needs tend to change the originality of some of the existing natural resources of which water is of no exception. Once these water resources are polluted, its quality cannot be restored by minimizing the factors that contribute to the pollution. The most common source of pollution of water is from substances used in forestry, waste and agriculture such as insecticides, herbicides, fungicides etc, and aerosols from pharmaceuticals and personal care products. The study was conducted to possibly determine the sources of pollution of a dam, a pond and two point boreholes that were actively in use by the people of Appiakrom community in the Sekyere Central District in Ashanti region of Ghana. Physical observation of site condition and community-based response survey were used with laboratory work being the main instrument for analyzing the physiochemical state and bacterial content of the water. The study revealed that the dam that supplied the whole district with water had been polluted as a result of anthropogenic activities that were evitable. The rusty nature of the undrinkable borehole was attributed to the underground parent materials in the area where the borehole was constructed. The Ghana Water Company Limited should therefore insist on the owners of the pond to resort to dug wells as their main source of water to the pond and block the channels constructed out of the dam to reduce the possibility of pollutants moving from the pond to the dam due to the pond-dam interface. Finally farmers around the bank of the dam should be entreated to practice zero fertilizer farming to avoid leaching of acid forming compounds into the dam.

KEY: Pond-dam interface, anthropogenic activity, zero fertilizer farming and pollution.

INTRODUCTION

The need (Essentiality and importance) of water in the lives of living organisms can never be undermined for its supportive role [1], [2], [3]. According to Gorde and Jadhav, (2013) it is one of the most important compounds that profoundly influence life. In spite of its enormousness, increasing the population of any country increases the demand for water supply [5], and everything needed by man for survival. Satisfying these anthropogenic needs tend to change the originality of some of the existing natural resources of which water is of no exception [3]. Once these water resources are polluted, its quality cannot be restored by minimizing the factors that contribute to the pollution. It therefore becomes very expedient to regularly monitor the quality of water, the pollutant levels and the possible sources of the pollution for better evaluation exercises with implications for public health, sanitation policy and planning, and sanitation design and development [6]. Tiimub et al, (2012) mentioned that the most common source of pollution of water is from substances used in forestry, waste and agriculture such as insecticides, herbicides, fungicides etc, and aerosols from pharmaceuticals and personal care products (PPCPs), and to Fetter, (1994) the constituents of these products are highly toxic, even in scanty quantities. Water resources assessment and evaluation for its quality, pollutant levels and sources of pollution become very keen for research in order to help the inhabitants of an area to know the effect of their activities on water quality, health and the environment [9], [10], because changes in the quality of water has a far reaching consequences in terms of its effects on man and biota [11]. In order to evaluate the quality of water, pollutant levels and pollution sources in a given area, the water chemistry and physics must be known [3]. This study was conducted to possibly determine the sources of pollution of a dam, a pond and two point boreholes that were actively in use by the people of Appiakrom community in the Sekyere Central District in Ashanti region of Ghana

MATERIALS AND METHODS

- **The States of the Sources of Water and the essence of inclusion**

Water from the two boreholes when fetch fresh was colourless, odourless and tasteless but upon standing for some time, water from the "undrinkable borehole" (the people in the community believed that there may be a mineral deposit beneath water table that might have cumulative effect hence the name undrinkable) develops a rusty colour which makes it tasteful. The Dam was constructed to supply water for the whole district. The dam when fetched untreated had a lot of dissolved particles which made it unclear, slightly tasteful and coloured. The pond which was used for fish farming had been constructed out of the dam in a sense that a channel has been made upon which water from the dam flows into the pond, likewise, water could flow from the pond to the dam should there be a flood (pond-dam interface)

Instrumentation

Physical observation of site conditions and community-based response survey were used with laboratory work being the main instrument for:

1. analyzing the physiochemical state of the water for Total Suspended Solids (TSS), Turbidity, Temperature, pH , Conductivity, Dissolved Oxygen, Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Iron, NO_3^--N, NH_3-N and Cl^-
2. analyzing water samples for bacteria – total coli form, E. coli, and Salmonella levels

- **Sample Collection**

Water samples were collected in clean 1500ml bottles from the study area. During the sampling, the area around the tip of the two boreholes where the water was directly drawn was disinfected using flames of candle burner. The sampling containers were autoclaved before using it for water collection. Sterilized forceps were used for holding and lifting the sampling containers before and after fetching the water. The containers were cap closed and the samples were gently transferred into an ice chest containing ice blocks to suspend bacteria growth in the

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process of transportation of water samples to the laboratory for analysis. The collected samples were then analyzed as quickly as possible within twenty four hours.

- **Quantitative Laboratory Analysis**

The analysis of water samples was done at the faculty of Science and Environment Laboratory of the University Of Education, Winneba-Mampong and Civil Engineering Department Laboratory at Kwame Nkrumah University of Science and Technology, Kumasi-Ghana. All the analyses were based on the standards described in the USEPA, Water Quality Standards; Review and Revision (2006)

Physical parameters

The total suspended solids of the water sample were determined by filtering the sample to dry the residue and determine the weight difference. Winkler method was used to determine the dissolved oxygen. Conductivity, temperature, pH and turbidity were measured using appropriate instrument below.

Parameter		Instrument used for measurement
Conductivity	:	LF 323 – B/Set
Temperature	:	Mercury-in-glass thermometer
pH	:	Digital pH meter (323-B/set-2)
Turbidity	:	Turbidimeter (Hach, 2100A)

Chemical Parameters

A five day incubation period was used to determine the Biochemical Oxygen Demand (BOD_5). Some water samples were evaporated to determine the total dissolved solids (TDS). Ferro Ver Method from the Hach programs was used to determine the iron content in the samples. Cadmium Reduction Method of the Hach programs was used to determine the nitrate content in the samples. Ammonia-Nitrogen was determined by selecting Hach Program 385 N, Ammonia- Salicylate Method.

Biological Parameters

Membrane filter technique using Chromocult Coli form Agar. After 24 hours under 35^{o}c of incubation, the number of Salmon to red colonies was recorded as coliforms by visual examination whiles dark-blue to violet colonies were recorded as E. coli. The sum of these two colonies was recorded as total coliforms

RESULTS AND DISCUSSION

Table 1.0 Physical parameters

Parameters	Sources of samples			
Mean value (unit)	A GM / SE	B GM / SE	C GM / SE	D GM / SE
Temperature (^{O}C)	27.5(±0.047)	27.6(±0.17)	28.1(±0.13)	28.8(±0.13)
Ph	5.8(±0.04)	5.6(±0.04)	6.3(±0.09)	6.7(±0.05)
Conductivity(µS/cm)	175.8(±4.04)	91.4(±0.37)	60.2(±1.85)	58.2(±0.07)
Turbidity (NTU)	2.2(±0.08)	0.8(±0.02)	25.8(±0.70)	94.6(±0.15)
DO (mg/L)	43.4(±0.5)	55.9(±0.9)	64.6(±0.55)	70.4(±0.23)
TSS	_	_	38.2(±0.47)	207.1(±0.4)

Key: *GM= Geometric mean, SE= Standard error, A= Undrinkable Borehole, B= Drinkable Borehole, C=Dam, D=Pond*

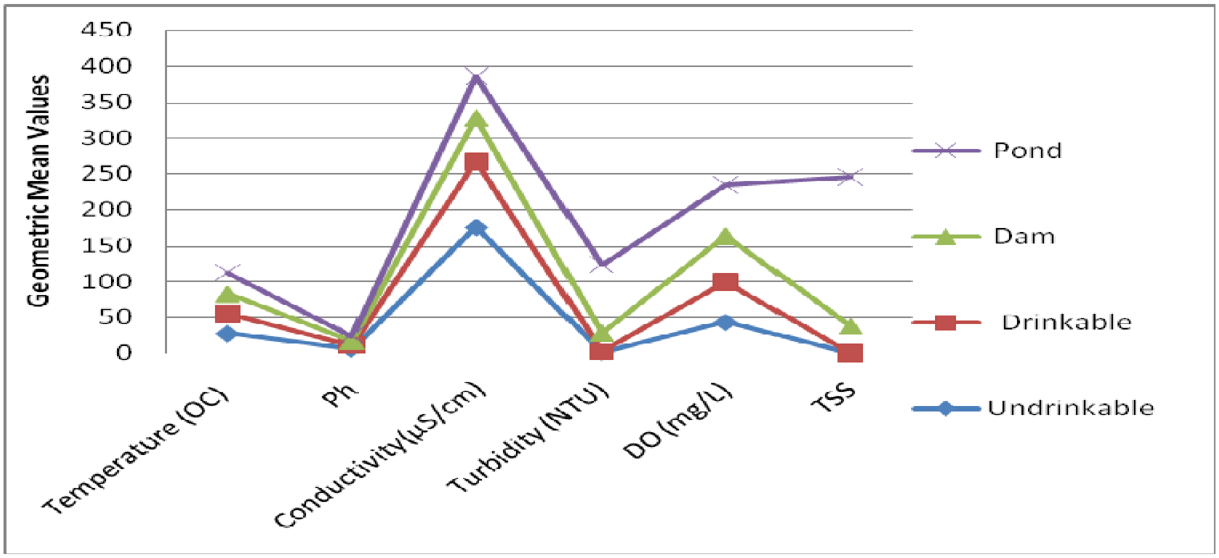

Figure 1.0 graphical presentation of physical parameters

- **Temperature**

There was statistically significant difference between mean temperatures of the groundwater sources when compared with the dam or fishpond ($P < 0.00$). The pond recorded the highest mean temperature 28.8(±0.13) during the study followed by the dam 28.1(±0.13) with the undrinkable borehole recording the minimum temperature of 27.5(±0.047). These high temperatures in the pond and dam could be attributed to the clearing of the vegetation just along the water bodies for farming purposes as well as for human settlement. This anthropogenic activity around the water bodies exposed the water to the direct beam of the sun.

- **pH**

The mean pH levels varied from 5.6±0.04 from the undrinkable borehole to 5.8±0.02 in the drinkable borehole source. Similarly, the pH of the two surface waters was higher when compared with the groundwater sources. It ranged from 6.3±0.09 in the dam to 6.7±0.05 in the fish pond. There was statistically significant difference between mean pH of the groundwater sources when compared with the dam or fishpond surface waters ($P < 0.00$). The slightly acidic nature of the water could be due to the release of acid-forming substances such as sulphate, phosphate, nitrates, etc. into the water. These substances might have altered the acid-base equilibrium and resulted in the reduced acid-neutralizing capacity [13]. True to Razak words, vegetables farmers at the upper bank of the dam usually apply fertilizers and pesticides on their field which gradually run into the lake water after heavy rainfall. These fertilizers may contain nitrate, sulphate and phosphate components [3].

- **Conductivity**

The conductivity of the two groundwater studied were higher as compared to that of the pond and the dam. The undrinkable borehole recorded the highest conductivity value meaning that it was suspected to have high inorganic dissolved particles. This could be attributable to the in situ material make up of the area where the borehole had been dug. Though the dam had significantly less conductivity value as compared to that of the boreholes but this value can be attributed to massive erosion of the area. Due to the topography (sloppy nature around the dam) of the area, erosion of inorganic materials during heavy rainfall from the farms around the dam found their way through the dam gradually increasing the conductivity. This was expected because the properties of conductivity are governed by the characteristics of the constituents inorganic salts dissolved in water.

- **Turbidity**

Turbidity of the two ground water sources was much lower than the levels detected from the two surface water sources. It ranged from 2.20±0.08 NTU in the undrinkable source to 0.8±0.02 NTU in the drinkable source, and 25.8±0.70 NTU to 94.6±0.15 NTU from dam to pond. The differences in mean turbidity levels between the two groundwater sources and the two surface waters were statistically significant ($P < 0.00$). The high values of turbidity in the surface water were attributed to several anthropogenic activities around the area. These activities indirectly contribute to the discharge of suspended matter into water during rainfall to displace settled matter, thereby reducing water clarity and transparency [13]. The relative high value of the undrinkable source as compared with the drinkable could be attributed to underground porous material that easily dissolved in the water

- **Dissolved Oxygen**

Concentrations of dissolved oxygen in the two boreholes were higher than that of the dam and pond waters. It ranged from 64.6±0.55mg/L in the undrinkable borehole to 70.4±0.23mg/L in the drinkable borehole and 43.4±0.5mg/L to 55.9±0.9 from dam to pond respectively. The differences in mean dissolved oxygen levels between the two groundwater sources and the two surface waters were statistically significant ($P < 0.00$). The USDA (1992) mentioned that, the level of oxygen depletion depends primarily on the amount of waste added, the size, velocity and turbulence of the stream, the initial DO level in the water and in the stream, and the temperature of the water.

Though there is an inverse relationship between temperature and DO, the levels of DO according to table 1 for the dam and pond should have been lesser as compared to that of the two boreholes based on temperature, then the high level of DO in the pond and the dam was attributable to the turbulence of the water.

- **Total Suspended Solids**

There was no detection of Total Suspended Solids (TSS) in all the two borehole water samples. However, there were visible suspended solid in the dam and the pond ranging from 38.2±0.47mg/L to 207.1±0.38mg/L, respectively with a significant difference ($P < 0.00$). This explains the kind of activity that goes on around the two surface waters. The high TSS level in the water was attributable to farming activities just around the bank of the dam. These made the land bare, prone to erosion thereby washing particulate matter into the water.

Table 2 Chemical parameters

Parameters (unit)	Sources of samples			
Mean value (unit)	A GM / SE	B GM / SE	C GM / SE	D GM / SE
BOD_5 (mg/L)	7.72(±0.19)	4.63(±0.21)	12.77(±0.14)	17.80(±0.29)
Iron (mg/L)	0.32(±0.005)	0.02 (±0.0)	0.01(±0.003)	0.52(±0.006)
T.D.S. (mg/L)	88.12(±2.19)	45.35(±0.88)	30.35(±1.00)	29.02(±0.23)
NO_3^{-}N (mg/L)	1.12(±0.01)	0.43(±0.01)	1.44(±0.01)	11.71(±0.07)
Ammonia (mg/L)	0.15(±0.004)	0.06(±0.001)	0.08(±0.003)	0.12(±0.102)
Chloride (mg/L)	0.3(-)	0.1(-)	0.1(-)	0.1(-)

***Key:** GM= Geometric mean, SE= Standard error, A= Undrinkable Borehole, B= Drinkable Borehole, C=Dam, D=Pond*

- **Biochemical Oxygen Demand**

The mean BOD_5 of the two boreholes were below the levels in the pond and dam. It ranged from 4.63±0.21mg/L in the drinkable hand-piped borehole to 7.72±0.19mg/L at the undrinkable hand-piped borehole and 12.77±0.14mg/L to 17.80±0.29mg/L from dam to pond respectively. The mean difference in BOD_5 levels between the ground and surface water sources was highly significant ($P < 0.00$). The high BOD_5 value in the pond and dam was attributable to organic waste such as human and animal excreta, refuse, etc discharged into the water, which required much oxygen in the oxidative breakdown of these wastes [13].

- **Total Iron**

The two borehole waters had iron concentrations ranging from 0.02±000 in the drinkable source to 0.32±0.005 in the undrinkable and 0.01±0.003mg/L to 0.52±0.006mg/L from dam to pond respectively. The mean difference in iron levels between the ground and surface water sources was highly significant ($P < 0.00$). Total iron concentrations in the pond and the undrinkable sources fell outside the “no effect” range of 0-0.3mg/l for drinking water use [15]. This could be a source of rusty colouration of the undrinkable source of water when it was made to stand still after fetching. There could be the possibility of the pond polluting the dam (the main source of water for the district) with iron due the pond-dam interface.

- **Total Dissolved Solids**

Total Dissolved Solids ranged from 45.35±0.88mg/L to 88.12±2.19mg/L in the drinkable to the undrinkable and 29.02±0.23mg/L – 30.35±1.00mg/L in the pond and dam respectively. The mean difference in TDS levels between the ground and surface water sources was highly significant ($P < 0.00$). The high value of TDS recorded from the undrinkable source could be attributed to the type of parent material (bedrock) at where the borehole was constructed.

- **Nitrate-Nitrogen (NO3-N)**

The NO_3-N levels in the dam and the pond ranged from 1.44±0.01mg/L to 11.7±0.07mg/L and from 0.43±0.01mg/L to 1.12±0.01mg/L in the drinkable and the undrinkable sources respectively. The mean difference in NO_3-N levels between the ground and surface water was highly significant ($P < 0.00$). The high level of NO_3-N in the pond could be attributed to formulated feed given to the fish in the pond as well as eroded materials from the nearby farms around the pond containing nitrogenous compounds. Some constituents might have leaked into the dam because of the pond-dam interface. Similar trends of groundwater pollution with nitrate had been observed in several peri-urban areas of developing countries where fertilizer use was on the rise [16].

- **Ammonia (NH3-N)**

The mean difference in NH_3-N levels between the ground and surface water sources was highly significant ($P < 0.00$) The mean NH_3-N levels in the two boreholes ranged from 0.15±0.004mg/L in the drinkable source to 0.06±0.001mg/L in the undrinkable and source and from 0.08±0.003mg/L to

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0.12±0.102mg/L in the dam and pond waters respectively. The ammonia levels in the pond and the dam could be attributed to the organic waste found in these water bodies. The ammonia content in the drinkable and the undrinkable could be due natural occurrence.

- **Chloride**

Apart from the undrinkable borehole water source where the mean chloride level was 0.3±0.004mg, the value of chloride from the other three sources was the same (0.1 ± 0.000mg) over the five months study period. The content in the undrinkable could be attributed to the mineral content of the place where the borehole was constructed.

Table 3 Biological parameters

Sampling sites	E. coli	Salmonella	Total coliform
A	Nil	4	6
B	Nil	Nil	Nil
C	5×10^2	8×10^2	4.5×10^3
D	3×10^4	5×10^4	3×10^4

A= Undrinkable Borehole, B= Drinkable Borehole, C=Dam, D=Pond

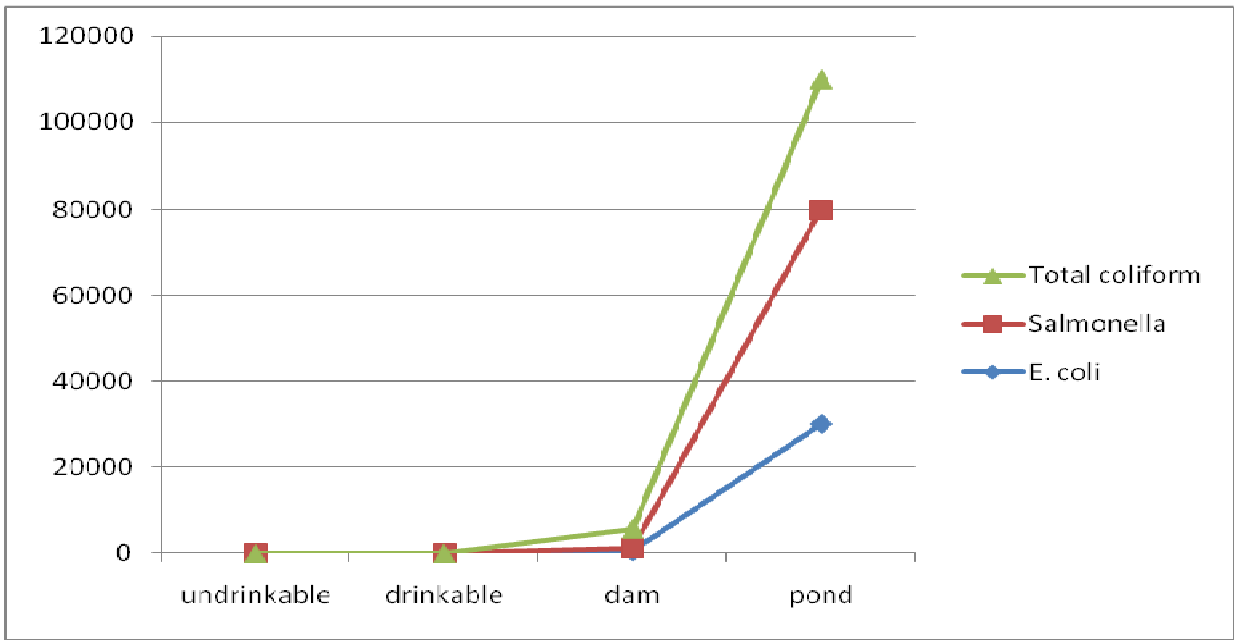

Figure 3.0 *graphical presentation of the biological parameters*

Apart from the drinkable source, the study detected the presence of varying microbial levels from all the sampling sites. E. coli was not present in the two boreholes but found in higher counts of 5×10^2 in the pond and 3×10^4 in the dam. There were salmonella count of 4, 8×10^2 and 5×10^4 per 100^{-ml} in the undrinkable borehole, dam and fish pond respectively. Total coliform of 6, 4.5×10^3 and 3×10^4 per 100^{-ml} of the water samples were detected from the undrinkable borehole, dam and pond respectively with a significant mean differences ($P < 0.000$) between their numbers The presence of the coliform bacteria was as a result of faecal matter from both animals and humans that have their way into the dam [13]. The high counts of faecal coliforms could be attributed to the indiscriminate defecation along the upper banks of the pond by both humans and other animals that grazed there. During the study it was realized that other animals like birds also swim in the dam and might possibly pollute the water. According to Jones & White (1984) birds "pollute" more faecal indicators than humans. This situation was comparable to the incidence of poor groundwater quality resulting from poor sanitation habits among the vulnerable groups in Ghanaian communities that was observed in areas of the Bawku East District of Upper East Region of Ghana where indiscriminate sitting of on-site sanitation facilities and improper liquid waste disposal methods contributed significant pollution trends to peri urban groundwater supplies where population growth was on the ascendancy and the people lack public health education [16]

CONCLUSION

The study revealed some important information about the quality of water supplied in Sekyere Central District of Ghana in respect to the pollutant levels and the sources of the pollution. The dam the supply the whole district with water had continually devalued as a result of a wide range of anthropogenic activities that were evitable. Agricultural activities, fecal discharge, indiscriminate destruction of vegetation cover around

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the dam and the pond were the main sources of this pollution. The rusty nature of the undrinkable source could be attributed to the underground parent materials in the area where the borehole was constructed. In view of this, there should be a holistic control of waste and fecal disposal into water sources because an intrusion of such waste substances into water bodies usually breed disease causing organisms; and its presence is detrimental to human safety and not even that they serve as adsorption sites for these pathogens should there be water treatment exercise. There should be an all level education on the need to protect, conserve and prevent water from being polluted from the identified sources so as to promote quality of the few available drinking water sources and safeguard its standards in the strive to meet consequential rising demands by majority of the growing population of people whole lack access to improved water supply in and around Appiakrom in the Sekyere Central District. The Ghana Water Company Limited should insist on the owners of the pond to source different water by dug wells and block the channels constructed out of the dam to reduce the possibility of pollutants moving from the pond to the dam due to the pond-dam interface. Finally farmers around the bank of the dam should be entreated to practice zero fertilizer farming to leaching of acid forming compounds into the dam.

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