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Correlation Analysis of Irrigation Water Quality parameter from the major rivers in the Amansie West District, Ashanti Region, Ghana

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ABSTRACT

A research was conducted at Amansie West District in the Ashanti Region of Ghana to establish the correlation between irrigation water quality parameters from the major rivers and their tributaries. Data collected were subjected to statistical analysis SPSS version 20. Pearson correlation coefficient was estimated to test the degree of relationship between irrigation water quality parameters. There was positive correlation between SAR and Ca, Mg, K, Na, ECw, and TDS except the ratio of Ca: Mg which showed negative correlation. Analysis of the correlation between SAR and HCO_3^- and CO_3^{2-} is highly recommended.

Keywords: Irrigation, Water Quality, Correlation, Rivers

I. INTRODUCTION

The mining industry is the backbone of many economics in the developing countries. Its recovery in Ghana since 1989 was compelled by the global paradigm which emphasizes private sector-led development as the engine of economic growth in developing countries. The historical importance of mining in the economic development of Ghana is evident in the country's colonial name, Gold Coast (Akabzaa T. and Darimani A., 2001).

The mining industry of Ghana accounts for 5% of the country's GDP and minerals make up 37% of total exports, of which gold contributes over 90% of the total mineral exports. Export earnings from minerals averaged 35%, and the sector is one of the largest contributors to Government revenues through the payment of mineral royalties, employee income taxes, and corporate taxes and employment generation. The mining industry therefore remains critical to Ghana's socio-economic growth and development. (Ghana Chamber of Mines, 2008).

Small and large-scale mining operations are inherently affecting the environment, producing enormous quantities of waste that can have negative impacts for decades (UNEP, 1997). Mining activities that affect water quality include the disposal of waste rock, tailings deposition, and effluent discharges from different stages of mineral processing (Dock, 2005). According to Ripley (1996) effluent released from gold mines is made up of heavy metals mainly from pyrite (FeS2) and chalcopyrite (CuFeS2). Koryak (1997) argues that the effluent produced from waste rock dumps has a potential of causing acid mine drainage (AMD) in stream and river waters.

An important chemical parameter for assessing the degree of suitability of water for irrigation is sodium content, which is expressed as the sodium adsorption ratio (SAR) measures the potential dangers posed by excessive sodium in irrigation water (Alagbe, 2006). When residual sodium carbonate (RSC) is positive, calcium is lost from the soil solution and increases SAR in the soil solution, thereby increasing the sodium hazard (Hopkins et al, 2007).

The quality of freshwater is mainly affected by natural processes such weathering and soil erosion as well as anthropogenic activities. The anthropogenic activity represents a constant polluting source whereas surface runoff is a seasonal phenomenon, mainly affected by climatic conditions (Singh et al., 2004). Water quality monitoring has a high priority for the determination of current conditions and long term trends for effective management.

The purpose of the study was to use correlation analysis in assessing irrigation water quality parameters of water from the major rivers and their tributaries in the Amansie west district.

II. METHODS AND MATERIAL

A. Description of the study area

Amansie West District is located in the Ashanti Region of Ghana, and it is an area where Galamsey activities (illegal mining) are very rampant (Figure 1).

Rivers served as a source of drinking water for the local people living in the area and currently serves as irrigation water for the farmers in the area especially during dry season and erratic weather condition.

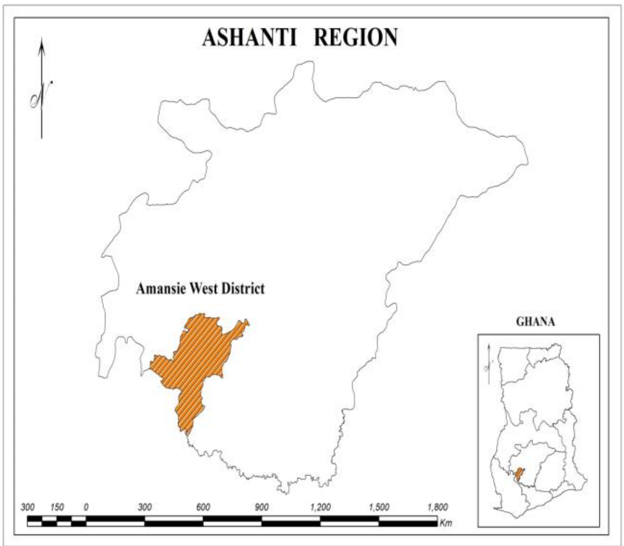

Figure 1: Map of Ashanti Region showing the location of the study area

The climate is characterized by a dry season between December and February, highest rainfall in June (major season), and a cooler and drier period in August with smaller rainfall in October (minor season).

The average monthly temperature ranges from 23.2^o C in August to 26.8^o C in February, and average monthly humidity range from 84.7% in August to 75.3% in January (Quansah et al., 2016).

The data used for the correlation analysis was obtained from the research previously done by Quansah et al, 2016. These data were used to estimate the Sodium Adsorption Ratio (SAR) and the ratio of calcium to magnesium.

B. Statistical analysis

Data collected were exposed to statistical analysis SPSS version 20. Pearson correlation coefficient was evaluated to test the degree of relationship between irrigation water quality parameters. This was calculated using the relation:

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{\left[n\sum x^2 - \left(\sum x\right)^2\right] * \left[n\sum y^2 - \left(\sum y\right)^2\right]}}$$

According to Pallant (2011, p. 134), a correlation coefficient can be described as: small correlation -0.10 ≤ r ≤ 0.29, medium correlation - 0.30 ≤ r ≤ 0.49 and large correlation - 0.50≤ r ≤ 1.0. The positive and the negative point to the direction of the relationship, where the positive indicates an increase in one variable associated with an increase in the other, whilst the negative correlation means an increase in one variable related to a decrease in the other. The coefficient of determination which explains the changes in one variable as explained by the changes in the other variable (r^2) was calculated.

III. RESULTS AND DISCUSSION

Tables 1 and 2 show average values of the irrigation water quality parameters and the correlation between these parameters from major rivers and their tributaries in the Amansie West District in the Ashanti Region of Ghana.

The range of pH in the samples is from 5.8 to 6.9 with mean of 6.5 which is moderately acidic and suitable for irrigation purpose according to Chiroma et al., 2014. (Table1). Temperature, electrical conductivity (EC_w) and

Total dissolve solids recode maximum of 24.30°C, 184.70µscm^{-1} and 92.50mg/l with mean of 24.09°C, 121.1 µscm^{-1} and 60.67mg/l.

A. Correlation analysis

From the Pearson correlation coefficient SAR showed positive correlation with Ca (+0.126), ECw (+0.025), K (+0.771), Mg (+0.100) and Na (+0.872), but the correlation is very strong in K^+ and Na^+ indication that an increase in Na^+ and K^+ lead to increase in SAR. This is so because SAR is determined using Na^+. This is expected for Na^+ since an increase in SAR indicate high availability of Na^+ in the irrigation water and hence in soils. A high SAR value implies a hazard of sodium (alkali) replacing Ca^{2+} and Mg^{2+} in the soil through a cation exchange process that damages soil structure, mainly permeability, and which ultimately affects the fertility status of the soil and reduces crop yield (Gupta, 2005).

SAR also showed weak negative correlation with Ca:Mg ratio and this could be explained by the fact that according to Michael, 1992, the bonding energy of Mg^{2+} is less than that of Ca^{2+}, allowing more Na^+ adsorption and this can be seen clearly when the ratio exceeds 4.0
The presence of high Na^+ in irrigation water promotes soil dispersion and structure breakdown when Na^+ to Ca^{2+} ratio exceeds 3.1(Michael, 1992). This also results in severe water infiltration problems, mainly due to insufficient Ca^{2+} to suppress the dispersing effect of Na^+ (Ayers and Westcot, 1985). Excessive Na^+ also creates problems in crop water uptake, poor seedling emergence, lack of aeration, plant and root disease (Ayers and Westcot, 1985).

TABLE I
MEAN VALUES OF THE IRRIGATION WATER QUALITY PARAMETERS

Sample	pH	Temp	EC$_w$	TDS	Ca
		°C	µscm^{-1}	mg/l	
Mean	6.451	24.09	121.1	60.67	6.77
Range	5.8-6.9	23.90-24.30	72.60-184.7	36.30-92.50	3.20-12.82

TABLE II
MEAN VALUES OF THE IRRIGATION WATER QUALITY PARAMETERS (CONTINUATION)

Sample	Mg	Na	K	Ca:Mg	SAR
	mg/l				
Mean	4.75	0.04	0.06	0.75	0.002
Range	1.46-7.78	0.01-0.07	0.010-0.013	0.30-1.33	0.001-0.004

TABLE III
CORRELATION COEFFICIENTS AMONG SELECTED WATER QUALITY PARAMETERS

Variates	Ca	Ca:Mg	EC$_w$	K
Ca	-			
Ca:Mg	-0.3796	-		
EC	0.7152	0.1275	-	
K	0.5157	0.0814	0.5172	-
Mg	0.5047	0.5538	0.8011	0.5779
Na	0.3955	0.0457	0.4214	0.9414
SAR	0.1256	-0.0682	0.0248	0.7705
TDS	0.7134	0.1286	1.0000	0.5160

TABLE IV
CORRELATION COEFFICIENTS AMONG SELECTED WATER QUALITY PARAMETERS (CONTINUATION)

Variates	Mg	Na	SAR	TDS
Ca				
Ca:Mg				
EC				
K				
Mg	-			
Na	0.4754	-		
SAR	0.0998	0.8716	-	
TDS	0.8013	0.4205	0.0233	-

4.75	0.04	0.06	0.75	0.002
1.46-7.78	0.01-0.07	0.010-0.013	0.30-1.33	0.001-0.004

IV. CONCLUSION

The quality of irrigation water available to farmers and other irrigators has considerable impact on what plant can be successfully grown, the productivity of these plants, water infiltration and other soil physical conditions. It is obvious that the quality are within the permissible limits for irrigation water and therefore suitable for irrigation purpose. SAR showed positive correlation with all the parameters except the ratio of Ca to Mg.

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