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ORIGINAL RESEARCH ARTICLE

INVESTIGATING THE POSSIBLE THREATS FROM VEGETAL COVER REMOVAL AND OPEN DUMPSITE TO GROUNDWATER QUALITY

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ABSTRACT

This study investigated the possible groundwater quality threats from excessive removal of vegetation due to urban growth in an open dumpsite in Waterloo, Brong Ahafo Region, Ghana. 15 water samples were collected from five (5) functional Hand-dug wells at increasing distance from the dumpsite. The samples were assessed for some physico-chemical parameters. Descriptive statistics were applied to investigate the quality of groundwater samples from the Hand-dug wells. The groundwater was slightly acidic. Total Suspended Solids (TSS) and Total Coliform count were high for the groundwater samples but total dissolved solids (TDS) were within the permissible limits of Ghana Ministry of Water Resources (GMWR) and WHO. Analysed parameters such as Ca2+, Na+, Cl- and Cu conformed to the prescribed limits of GMWR and WHO for drinking water while Pb was above the permissible limits of both. Fe2+ conformed to the limit by GMWR but was above WHO. Cd was above the permissible limit of GMWR but fell within that of WHO. Urban growth effects investigated through the use of Landsat images of 1986, 2000, 2006 and 2011 with the aid of ArcGIS 10.5 and ENVI 4.7 revealed that the study area, within these years, drastically reduced in forest cover due to the increase in built-up and has the tendency to cause contamination to groundwater in the area.

1.0 Introduction

The reliance on groundwater is gradually increasing due to its perceived quality. However, with the increase in human population and the negligence exhibited towards waste management, groundwater is now susceptible to pollution from the increased wastewater generated due to increased human population. In developing countries especially, waste management has been reported to be an environmental and public health problems (Akoteyon et al., 2011). In many developing countries like Ghana, the most common method of waste disposal is through the Land filling or Open dumps. The dumping of solid waste in uncontrolled landfills can cause significant impacts on the environment and human health (Dong et al., 2008). The pollutant that infiltrate from dumpsite has once been described as the worst threats to groundwater quality

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(Mor et al., 2005). When waste is disposed at landfills, it undergoes series of physical, chemical and microbiological changes that results in the release of a toxic liquid known as leachate, which contains numerous organic and inorganic compounds. The leachate will continuously migrate through the soil strata, eventually contaminating the groundwater system if not prevented (Kanmani and Gandhimathi, 2013). The Sunyani Municipal in Ghana has a main dumpsite where all wastes generated within the municipality are dumped. This municipal dumpsite is situated within 700m radius of several Hand-dug wells that serve as a source of water for drinking and irrigation for the Waterloo community. Continued drinking of water from these wells may impair the health of the inhabitants because of its negative effects on the irrigated crops. Exposure of waste dumpsites to storm water, results in the flow of liquid, salts, organic and inorganic compounds out of the dumpsite and predictably into surface or groundwater sources causing contamination (Ewemoje et al., 2017). On this basis, it is necessary to understand the current and potential impacts on groundwater sources in Sunyani Municipality with a view to assessing the impacts of removal of vegetal cover in the area leading to increased built-up area and its attendant effects on groundwater quality and quantity within the municipality.

2.0 Methodology

2.1 Location of the Study Area

Sunyani is a city in the Republic of Ghana and is the capital of Sunyani East Municipal District and Brong Ahafo Region (Figure 1a). The Sunyani Municipal Assembly covers a total land area of 506.7 km2. It lies approximately between Latitudes 7.20°N and 7.05°N and Longitudes 2.30°W and 2.10˚W (Table 1). It is bordered on the north by Sunyani West District; west by Dormaa East District, south by Asutifi District and east by Tano North District. Sunyani also lies within the middle belt of Ghana between 750 (229 meters) to 1235 feet (376 meters) above sea level (googleearth.com). The city falls within the wet Semi-Equatorial Climatic Zone of Ghana. The mean monthly temperature varies between 23°C and 33°C with the lowest temperature observed around August and the highest around March and April. The relative humidity is high, averaging between 75 and 80 % during the rainy seasons and below 70 % during the dry seasons of the year, creating an ideal climate for luxurious vegetative growth. The city experiences a bi-modal rainfall pattern with the main rainy season being between March and September and the minor between October and December (Sunyani Municipal Assembly, 2014). Figure 1b is a view of the Sunyani Municipal Dumpsite and its features are shown in Tables 2 and 3.

Table 1: Sunyani dumpsite location data

Parameter	Location
Landfill Longitude	2.320° W
Landfill Latitude	7.290° N
City/Town	Sunyani
Administrative Area	Sunyani Municipal Area

Source: (Sunyani Municipal Assembly, 2014)

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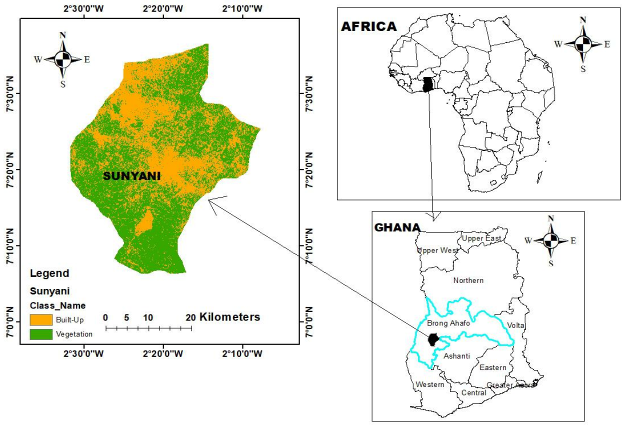

Figure 1a: Map of Sunyani Municipal

Figure 1b: A view of Sunyani Municipal Dumpsite

Table 2: Sunyani dumpsite physical data

Parameter	Description
Landfill Type	Open Dump
Landfill Size – Designed Area	25 hectares
Designed Capacity	
Average Waste Depth	About 1.5m
Waste Types Accepted	MSW, Septage
Year Filling Began	1998
Closure Year	

Source: (Sunyani Municipal Assembly, 2014)

Table 3: Site facilities and infrastructure data

Parameter	Description
Weighbridge	None
Fencing	None
Leachate Collection	None
Gas Collection	None
Treatment Ponds	None

Source: (Sunyani Municipal Assembly, 2014)

2.2 Experimental Design

Water samples from Hand-dug wells located in Waterloo community downstream of the dumpsite were collected and analysed. The sampling was undertaken between 18th and 20th January, 2018. Purposive sampling method as reported by Ewemoje et al. (2017) was employed to collect the groundwater samples from Hand-dug wells (GW1, GW2, GW3, GW4 and GW5), out of 7 Hand-dug wells (2 collapsed), which were within 700m radius from the dumpsite. A total of 15 water samples were collected from each of the Hand-dug wells for analysis. The water samples were collected from the wells using drawing buckets tied with ropes. The groundwater samples were then collected in acid-washed polyethylene bottles of 1L capacity after rinsing with the sample. All samples were preserved in ice cooler to control effects of ambient temperatures on the sampled water to avoid deterioration of the samples. The GPS

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coordinates for each sampled Hand-dug well and the dumpsite were recorded using GPS Garmin eTrex10. A water sample location map was created from the collected GPS coordinates using ArcGIS 10.5 (Figure 2).

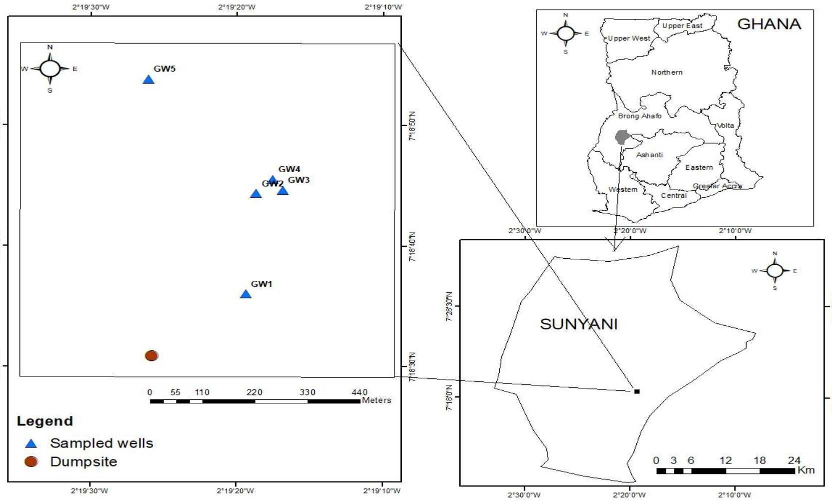

Figure 2: Water sample location map

2.3 Analytical Procedures

All the samples were taken to the Civil Engineering Laboratory at Kwame Nkrumah University of Science and Technology for analyses. The pH was measured using the PC 300 Waterproof Handheld pH meter, Total Suspended Solids (TSS) using the gravimetric determination, Total Dissolved Solids (TDS) using the HACH Conductivity-TDS meter. Total Coliform count was examined through the Membrane Filter Technique using Chromocult Coliform Agar. Cadmium (Cd), Iron (Fe^{2+}), Lead (Pb) and Copper (Cu), were tested using the Atomic Absorption Spectrophotometer (A.A.S) in the water samples (Ackah, 2011). The sample aliquot was absorbed in nitric acid, diluted appropriately, then aspirated and the absorbance was then measured spectrometrically for each of the trace elements being tested. Sodium (Na+) and Calcium (Ca^{2+}) were analysed using a Sherwood model 420 flame photometer. Chloride (Cl-) was analysed using the Argentometric method following protocols by the American Public Health Organisation (1992). Values obtained from these analyses were compared with the minimum standards set by the Ghana Ministry of Water Resources (GMWR) and World Health Organisation (WHO).

Descriptive statistics were used to describe the basic features of the data in the study. They provide simple summaries about the sample and the measures. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data. Descriptive statistics simply describes what the data is, and what it shows (Trochim, 2002). Microsoft Excel 2013 was used to compute the descriptive statistics from the replications of the analysis and the results presented in a table.

2.4 Hydro-chemical Data Validity Checks

Hydro-chemical data obtained from laboratory analysis in the study area were subjected to internal consistency tests. The concentration of the major anions and cations were compared to ensure that these concentrations were within ±5 of each other, using the charge balance error formula presented in Equation (1) (Hounslow, 1995).

$$\text{Charge Balance Error} = \frac{\sum\text{Cation}-\sum\text{Anion}}{\sum\text{Cation}+\sum\text{Anion}} \times 100\% \qquad (1)$$

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where: ΣCation is the sum of cations and ΣAnion is the sum of anions. According to Hounslow (1995), if the electrical balance calculated is less than 5%, then the analysis is assumed to be good and if it is greater than 5% the analysis is supposed to be poor or some missed constituent were not included in the calculation or the water is very acidic. The hydro-chemical data from the laboratory analysis of the water samples had charge balance error less than 5% and were permitted for further descriptive statistics.

2.5 Land Use/Cover Change analysis in the Study Area

To examine how vegetal cover in the area has been replaced with Built-up and its potential impact on the groundwater quality of Waterloo, Landsat 7 ETM+ images of the area, for the years, 1986, 2000, 2006 and 2011 were obtained from the U.S Geological Survey archives. These images were processed to know whether changes that have occurred in the area are as a result of urban growth. The images were analysed using ENVI Version 4.7, ArcGIS Version 10.5 and MS Excel 2013. Data sets used for the study, their source and date of acquisition are shown in the Table 4.

Table 4: Landsat Images used in the analysis of the study area

Landsat	Satellite sensor	WRS Path/Row	Date of Acquisition	Spatial Resolution	Spectral Resolution	Source
1	Landsat 7 ETM+	195/055	20/11/1986	30m	8 Bands	GLCF
2	Landsat 7 ETM+	195/055	2/2/2000	30m	8 Bands	GLCF
3	Landsat 7 TM	195/055	5/5/2006	30m	8 Bands	GLCF
4	Landsat 7 TM	195/055	5/5/2011	30m	8 Bands	GLCF

2.6 Methods of Image Analysis

2.6.1 Accuracy Assessment for Landsat Images

Accuracy assessment is an integral step in analysing any land classification. Accuracy assessment is the process by which the accuracy or correctness of an image classification is evaluated. It involves comparing the classified image to reference data that are assumed to be true (Maus and Golden, 1996). The assessment helps to determine whether or not the classified image is feasible depending on the acceptable level of error in the image. By selecting Region of Interests (ROIs) identified in the image and which are evenly distributed, the accuracy level of the map can be determined. Equal number of pixels selected for the ROIs is not advisable as some classes may have larger number than others (thus, the larger the class, the more the pixels).

2.6.2 Image Pre-processing

For analysing the change in the land cover, radiometric and geometric restorations are crucial in every remotely sensed data analysis. Geometric restoration gives the accurate orientation of the satellite images, thus georeferencing the image. The acquired images had already been georeferenced from the World Geodetic System (WGS 1984). They were re-projected to the coordinate system of the study area. That is, Universal Transverse Mercator (UTM Zone 30 North, Ghana) using ENVI Version 4.7. Radiometric restoration removes or suppresses the degree of spectral differences emanated from each detector causing distortion in the imagery. Examples of such distortions are striping, scan line drop-out and atmospheric haze. The data-sets that were mostly affected by these distortions were the Landsat 7 imageries for the years 2006 and

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2011. Landsat 7 TM developed a scan line corrector failure which made it impossible to have a correct image for the entire area [USGS, 2010]. The scan lines in the imagery were removed using the gap-fill method in ENVI Version 4.7.

2.6.3 Image Enhancement

This method deals with modifying or improving the quality of the image, making it more suitable to be perceived by the human eye. In order to improve the visibility of the images, a colour composite for the images were established using Landsat ETM+/TM bands 4, 3, 2, (Near infrared, Red and Green) which were layer stacked for 1986, 2000, 2006 and 2011 images and created a false colour composite images in ENVI Version 4.7 (Figure 3). The false colour composite was selected because vegetation usually reflects an infrared colour, thus they appear in shades of red/dull red to pinkish smooth, Built-up/urban areas in cyan blue, and soils vary from light brown and water appears very dark (Desai, 2014).

2.6.4 Change Detection and Analysis

Change detection measures the changes that have occurred in an area over a period of time. The study revealed the percentage cover change detected over the different years observed with regards to the Landsat Images Analysed in ArcGIS 10.5 and ENVI 4.7. This was known by multiplying 30m×30m (i.e. 900 Sq. meters /0.09 ha) to give the area of each raster cell in projection.

For each class, the cell area was then multiplied with their respective cell count (Table 5) and final values were then multiplied by 100 to give the percentage cover change for each year.

3.0 Results and Discussion

The preliminary results of Euclidean distance function performed in ArcGIS Version 10.5 to determine the distance of each sampled Hand-dug well from the dumpsite was given in Table 5.

Table 5: Sampled Wells and their distance from dumpsite

Wells	Distance from Dumpsite (m)
GW1	300.37
GW2	460.15
GW3	471.34
GW4	490.72
GW5	664.63

3.1 Change Detection Measure

The percentage cover change detected over the different years observed with regards to the Landsat Images Analysed in ArcGIS 10.5 and ENVI 4.7. This is illustrated in Table 6 and Figure 3 respectively.

3.2 Physico-chemical Characteristics of Groundwater Samples

The groundwater samples are slightly acidic with pH ranging from 5.13-7.78 corresponding to a mean value of 6.19 ±0.924 (n = 5). The values of TSS varied between 2-144 mg/L. The TDS in the groundwater samples varied between 33.91-176.08 mg/L. Total Coliforms observed in the groundwater were very high with values between 143-300 CFU/100ml. Iron (Fe^{2+}), Calcium (Ca^{2+}) and Sodium (Na^{+}) varied respectively between 0.179-0.466 mg/L with a mean value of

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0.29±0.102 mg/L (n = 5), 2.4-37.68 mg/L with a mean value of 13.47±12.538 mg/L (n = 5) and between 5.214-11.448 mg/L with a mean value of 6.84±2.388 mg/L (n = 5). The proportion of Chloride (Cl-) present in the groundwater samples ranged between 18-46 mg/L with a mean value of 27.4±9.731 mg/L. The concentrations of Cadmium (Cd), Lead (Pb) and Copper (Cu) varied respectively between 0.005-0.023 mg/L (mean value of 0.01±0.006 mg/L; n = 5), 0.023-0.038 mg/L (mean value of 0.03±0.005 mg/L; n = 5) and between 0.117-0.158 mg/L (mean value of 0.13 ±0.014 mg/L; n = 5) (Table 7).

Table 6: Land Use Land Cover (LULC) Cell counts

LULC Category	1986	2000	2006	2011
Vegetation	738777	729101	34746	10717
Built-up	785561	795237	1489592	1513621

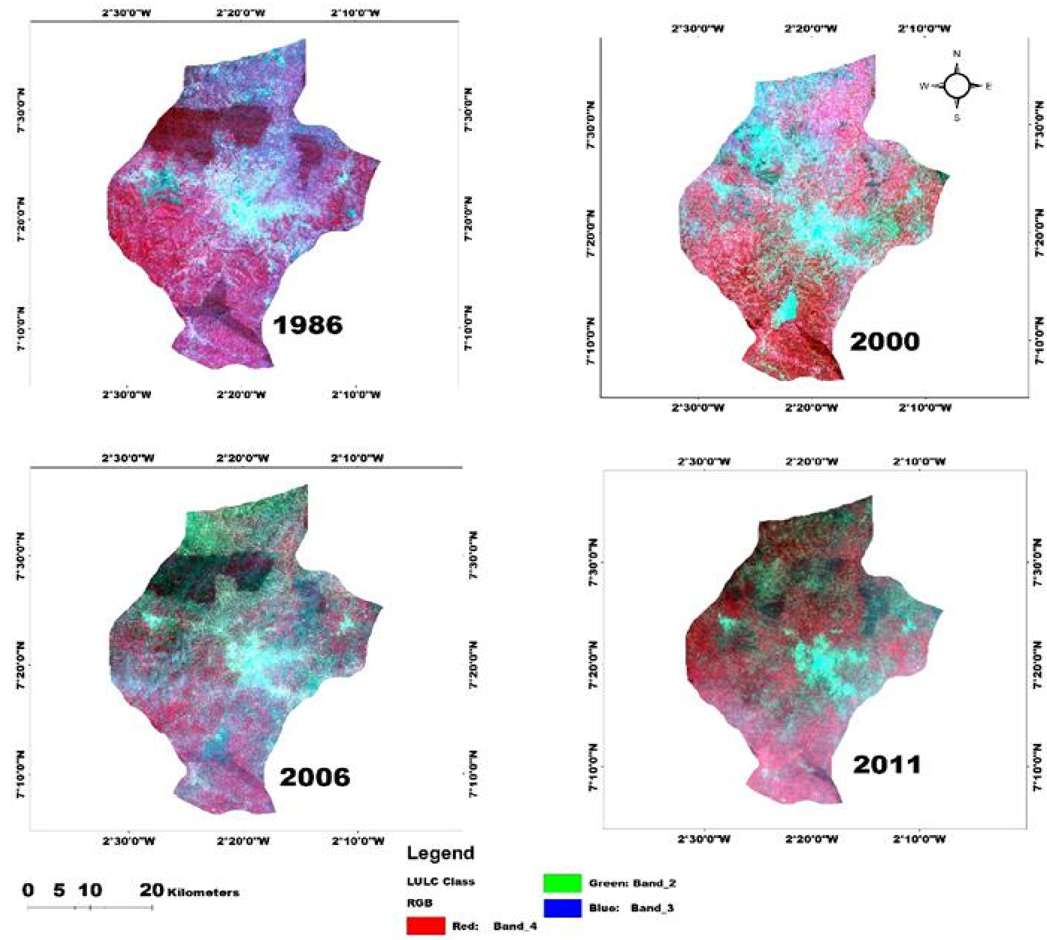

Figure 3: False colour composite of Landsat Images

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Table 7: Physico-chemical results of groundwater samples

	Hand Dug Wells								Standard	GMWR	WHO
Parameters	GW1	GW2	GW3	GW4	GW5	Min	Max	Mean	Deviation	(2015)	(2014)
pH	6.7	5.21	5.65	5.71	7.68	5.13	7.78	6.19	±0.924	6.5-8.5	6.5-8.5
TSS (mg/L)	15	45	7.33	92.67	3	2	144	32.60	±41.862	0	0
TDS (mg/L)	173.8	34.45	48.4	41.81	81.4	33.91	176.08	75.97	±53.301	1000	600
TC CFU/100ml	250.67	290	287.33	147	238.67	143	300	242.73	±56.533	0	0
Fe^{2+} (mg/L)	0.18	0.29	0.46	0.3	0.21	0.179	0.466	0.29	±0.102	0.3	0.01
Ca^{2+} (mg/L)	35.27	2.67	4.01	8.01	17.37	2.4	37.68	13.47	±12.538	200	200
Na^{+} (mg/L)	11.34	5.42	6.69	5.44	5.3	5.214	11.448	6.84	±2.388	200	200
Cl^{-} (mg/L)	45.33	22.33	25.67	24	19.67	18	46	27.4	±9.731	250	250
Cd (mg/L)	0.005	0.012	0.014	0.021	0.015	0.005	0.023	0.01	±0.006	0.003	0.01
Pb (mg/L)	0.026	0.037	0.023	0.028	0.033	0.023	0.038	0.03	±0.005	0.01	0.01
Cu (mg/L)	0.12	0.15	0.13	0.12	0.11	0.117	0.158	0.13	±0.014	2	0.4

TSS: total suspended solids; TDS: total dissolved solids; TC: total coliform count; GW: Hand-dug wells; Min: Minimum; Max: Maximum; GMWR: Ministry of Water Resources, Ghana; WHO: World Health Organisation

3.3 Accuracy Assessment for Landsat Images

The accuracy assessment was performed on the classified image using ENVI 4.7 version (Figure 4). Through the application of Post Classification analysis, a Confusion Matrix was done for the Regions of Interest (ROIs) (i.e. Vegetation and Built-up). Confusion Matrix composed of the Kappa coefficient (k), Overall accuracy, Producer's accuracy (Errors of Omission), User's accuracy (Errors of Commission). Overall accuracy is the total accuracy of the classified image. Errors of Omission occur when a pixel is left out of the category being evaluated. Errors of Commission result when a pixel is incorrectly included in the category being evaluated. Kappa coefficient (k) gives a discrete multivariate technique used in accuracy assessment, thus k>0.80 gives a strong accuracy of the class assessed, 0.40 – 0.80 is average and < 0.40 is poor (Tables 8 and 9).

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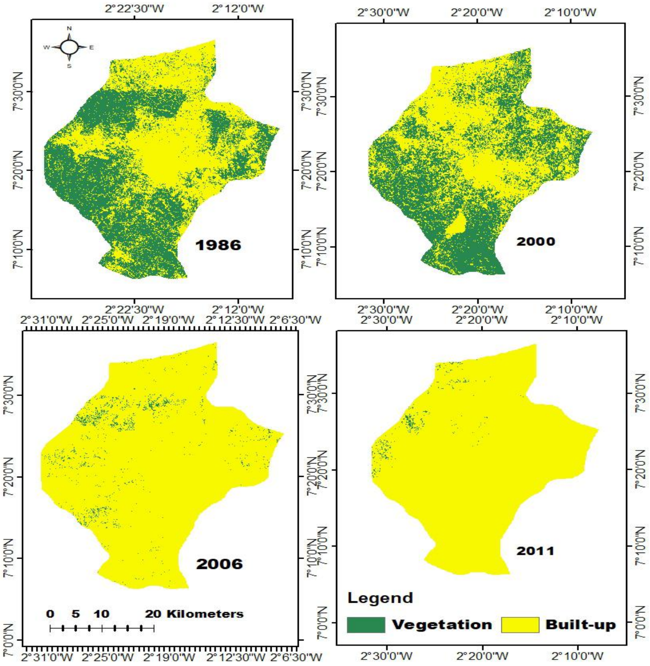

Figure 4: Land Use/Cover map of Sunyani (1986-2000; 2006-2011)
Source: (Sunyani Municipal Assembly, 2014)

Table 8: Summary of Overall Accuracy and Kappa coefficient

Year	Classified Image	Overall Accuracy (%)	Overall Kappa Coefficient (k)
1986	Landsat7 ETM+	99.98	0.999
2000	Landsat7 ETM+	100	1
2006	Landsat7 TM	100	1
2011	Landsat7 TM	99.97	0.999

Table 9: Summary of User's and Producer's Accuracy

	Vegetation		Built-up	
Year	User's Accuracy (%)	Producer's Accuracy (%)	User's Accuracy (%)	Producer's Accuracy (%)
1986	100	99.98	99.96	100
2000	100	100	100	100
2006	100	100	100	100
2011	99.87	100	100	99.97

3.4. Change Detection Results for Landsat Images (1986-2000, 2006-2011)

The changes that have occurred in the area between the periods of 1986 to 2011 are shown in Table 10.

Table 10: Land Use Land Cover distribution

	1986		2000		2006		2011	
LULC Category	Area (Ha.)	Area (%)	Area (Ha.)	Area (%)	Area (Ha.)	Area (%)	Area (Ha.)	Area (%)
Vegetation	66489.93	48.47	65619.09	47.83	3127.14	2.28	964.53	0.7
Built-Up	70700.49	51.53	71571.33	52.17	134063.3	97.72	136225.9	99.3

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3.5 Discussion

3.5.1 Physico-chemical characteristics of groundwater

The range of groundwater pH values reveals that the samples are slightly acidic. This could be attributed to discharge of acidic water into these sources from the dumpsite leachates, agricultural and domestic activities in the study area (Brian, 2012; Nyamekye, 2013). Acidic water enhances the potential of dissolved rock minerals to release harmful trace metals into water making it toxic for human consumption (Obeng, 2015). Also, with acidic water, the growth and proliferation of microorganisms including coliforms tend to increase and this might affect the safety of the water for drinking purposes (Mario et al., 2017). The Hand-dug wells recorded a concentration of TSS above the GMWR (2015) and WHO (2014) permissible limits of 0 mg/L for drinking water.

Poor management practices from activities such as construction and agriculture can strip vegetation and allow the quick influx of sediments into groundwater via overland flow (Sharp, 2010). This could also be attributed to the likelihood of sediments entering the Wells since they are open dug. TDS values recorded for the groundwater samples were below the criteria set by both GMWR and WHO. However, the observed TDS concentration may arise from the removal of grassland in the study area, which could have help to filter out sediments and associated nutrients (Lee and Isenhart, 2000).

According to WHO (2006), there has not been any deleterious physiological reactions occurring in persons consuming drinking water that have TDS values in excess of 1000mg/L. (Kempster et al., 1997) reported that the consumption of water with a critical TDS value of >1000 mg/L may result in some long term health problems due to excessive concentrations of dissolved particles in drinking water. The groundwater showed a concentration of total coliform above the prescribed limits of GMWR and WHO. This could be from the disposal of faecal matter by waste management companies in an area close to the dumpsite, domestic animal droppings as well as from the dumpsite which lies uphill of the Wells.

Consumption of the groundwater can cause numerous cases of illness such as ear and eye discharges, skin rashes and gastrointestinal problems as revealed by recent study of Chithra et al. (2015). The concentration of Iron (Fe^{2+}) was found to conform to the permissible limit of GMWR but was above that of WHO for drinking water. The presence of Fe^{2+} in the groundwater samples might be from the migration of leachates from the dumpsite into the Wells as suggested by Denutsui et al. (2012) and Osei et al. (2011) from their study on abandoned waste disposal sites. Also, the presence of Iron in the groundwater could partly be from the Windlass fixed on the Wells which helps in drawing the water as well as infiltration from the heap of scrap metals gathered by scrap dealers as observed in the study area. It has been remarked by Akinbile (2006) and Shyamala et al. (2008) that the formation of blue baby syndrome in babies and goitre in adults are the results of consumption of water containing Iron above the specified quantity.

An essential element that is present in the human body is Calcium. The concentration of Ca^{2+} was within the permissible limits of GMWR and WHO. Calcium ion (Ca^{2+}) can occur naturally in groundwater through the dissolution of carbonate minerals and the decomposition of sulphate, phosphate and silicate minerals (Cabbina et al., 2012). The concentration of Na^{+} in the groundwater was within the acceptable standard of GMWR and WHO. However, the presence of

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Sodium might be from releases from the dumpsite and domestic wastes. Also, Sodium is often naturally found in groundwater but can also result from sources such as road salt, water softeners, natural underground salt deposits, pollution from septic systems (WHO, 1979). The concentrations of Cl- in the groundwater were within the acceptable limits of GMWR and WHO. High concentration of Chloride in drinking water gives a salty taste and has a laxative effect on people not accustomed to it (Ackah, 2011).

The concentrations of Cadmium in the groundwater samples were above the acceptable standards of GMWR but fell within WHO. The presence and high levels of Cadmium observed may be attributed to the fact that the dumpsite receives paint pigment wastes, and the burning of Cadmium-containing PVC plastics (Dadzie, 2012). This makes the groundwater not suitable for drinking as its accumulation over a period of time can result in health problems. Lead (Pb) concentrations in the groundwater were far above the GMWR and WHO permissible limits. Possible sources of lead contamination may be batteries, photographs, old lead-based paints and lead pipes disposed at the landfill, which are toxic to all forms of life (Al-Yaquot and Hamoda, 2003).

This result could be alarming to public health and for the environment because heavy metals such as Lead is a carcinogenic substance and can adversely affect mental and neurological functions as well as altering metabolic processes in the human body system (Adeyi and Majolagbe, 2014). Copper concentration in the groundwater samples were below the GMWR and WHO standards. The presence of Copper in the groundwater samples, however, might be from migration of leachate from the dumpsite and domestic waste waters. Leachate from a solid waste disposal site is generally found to contain trace metals like Copper as suggested by a study of Freeze and Cherry (1979).

3.5.2 Land Use Land Cover changes in the study area

A Land Use Land Cover change in the study area based on two classes (i.e. Vegetation and Built-up) is presented in Figure 4. The expansion of cities is generally at the expense of destruction of forests and other natural ecosystems, thereby resulting in the increase in both air and water pollution (AfDB, 2012). It was discovered from the classified Landsat scenes that the year 1986 had a forest cover spanning a percentage area of 48.47% whilst 51.53% represented Built-up areas. However, in the year 2000, it was revealed that the area of land with vegetation had reduced to 47.83% whereas the land area for Built-up increased to 52.17%; in 2006, vegetal cover for the study area was revealed to be 2.28% with Built-up covering an area of 97.72% and in the year 2011, vegetation was discovered to have further reduced to a percentage area of 0.7% whereas Built-up further increased to cover a percentage area of 99.3% (Table 10).

The upsurge in population in the study area is contributing to the depletion of biodiversity resources. It has also led to congestion thereby driving it towards increased demand for land resources (Sharma et al., 2012). This has adverse effects on both surface and groundwater resources because whatever happens on the land eventually ends in water bodies (Randolph, 2012). As stated by Forster and Cherlet (2012), the removal of vegetation has a major influence on both groundwater quality and recharge rates.

Significant Land-use change such as clearing of natural vegetation and forests, can have long lasting, and in some cases, irreversible impacts on aquifers; it can result in the mobilization of salt from sub-soil zone and a significant increase in recharge rate on flat grounds. The removal

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of vegetation in the area to cater for urban developments will also lead to increased imperviousness, which in turn induces more total runoff capacity. High percent impervious surface has been associated with increase in urban growth and a decrease in surrounding water quality because greater pollutant loads are transported to runoff flow channels (Brabec and Schulte, 2002). Increase in impervious cover and runoff directly impact the transport of non-point source pollutants including disease-causing organisms from failing septic systems, nutrients, toxic contaminants, and sediment (Hurd and Civco, 2004; Schueler, 1987).

The transport of these highly potential pollutants through storm water runoff can in certain weather conditions degrade soil and percolate underlying layers thereby contributing to the degradation of groundwater quality (Chithra et al., 2015). Grasslands, in particular, help to filter out sediments and the associated nutrients (Lee and Isenhart, 2000), therefore provide an essential and unique way of improving water quality. Hence this could render groundwater in the area susceptible to contamination.

4.0 Conclusion

The study reveals the case of Waterloo community, where inhabitants primarily rely on groundwater within at least a 700m radius from a dumpsite, as a major environmental concern. The physico-chemical analysis from the study revealed that the groundwater samples are slightly acidic (pH = 5.13-7.78). TSS (2-144 mg/L) and Total Coliform (143-300 counts/100ml) were above the acceptable limits of both GMWR and WHO while TDS (33.91-176.08 mg/L) fell within the permissible limit of both GMWR and WHO.

Parameters such as Ca^{2+}, Na^{+}, Cl^{-} and Cu with the mean values of 13.47±12.538 mg/L, 6.84±2.38 mg/L, 27.4±9.731 mg/L and 0.13±0.014 mg/L respectively were within the prescribed limits of both GMWR and WHO. Other parameters such as Pb, with the mean vale of 0.03±0.005 mg/L had a relatively high value that deviated from the acceptable limits of both GMWR and WHO; Fe^{2+} with the mean value of 0.29±0.102 mg/L conformed to the limit by GMWR but was above the permissible limit set by WHO, and Cd with the mean value of 0.01±0.006 mg/L, was also above permissible limit by GMWR but fell within the acceptable criteria by WHO. The groundwater in Waterloo is therefore not recommendable for drinking.

Analysis of the forest cover in the study area through the aid of Landsat images revealed that in the in the year 1986, the study area had 48.47% forest cover and Built-up area of 51.53%; in the year 2000, percentage vegetal cover had reduced to 47.83% and Built-up area increased to 52.17%; in the year 2006, percentage vegetal cover disturbingly reduced to 2.28% and Built-up area increased to 97.72% and finally, in the year 2011, the study area had its percentage vegetal cover reduced to 0.7% with Built-up area increasing to 99.3%. This extent of vegetation removal has the likelihood of inducing high runoffs and if pollutants within these runoffs are able to infiltrate the soil, they can have the potential to degrade groundwater quality in the area. This, therefore, is a major concern that requires necessary attention in Waterloo.

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