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ASSESSMENT OF GROUNDWATER HEAVY METAL CONTAMINATION IN HADEJIA METROPOLIS, JIGAWA STATE, NIGERIA

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ABSTRACT

Heavy metal content in groundwater sources is of growing concern, as they are known to be persistent in nature and have been found to bio-accumulate in animals and plants. They have been found to cause detrimental health effects to human beings; therefore these necessitate the need to assess level of heavy metals in water sources. This study was carried out to evaluation the quality of groundwater samples from twenty five selected boreholes in Hadejia and Atafi Districts of Hadejia Local Government Area, Jigawa State, Nigeria. Selected heavy metals:- Cadmium, Chromium, Iron, Manganese and Lead were determined using atomic absorption spectrophotometry. The results showed that concentrations of Cr(0243 – 0.358mg/L), and Fe(0.967 – 1.359mg/L) were found to be above the maximum permissible limit of Nigerian Standard for Drinking Water Quality and World Health Organization, while, Cd, Mn, and Pb concentrations are below or within the permissible limit in majority of the boreholes. The values for physicochemical variables pH, and TDS were found to be below or within the permissible limit set by the World Health Organization and Nigerian standard for Drinking Water Quality. There is a growing concern about the dangerous health implication of hexavalent chromium consumption in drinking water. It can cause skin and eye irritation, asthma, nasal ulcers, convulsions, acute gastroenteritis, and damage to the liver and kidneys. High iron in water content leads to an overload which can cause diabetes, hemochromatosis, stomach problem, and nausea, it can also damage the liver, pancreas, and heart. It is necessary to clarify the origin, the mode of action, and the negative impact has on human, to create appropriate preventive and intervention measures.

Keywords: Heavy Metals, Groundwater, Contamination

INTRODUCTION

Water is an essential resource that is abundantly utilized all over the world in agriculture, transport, industries and domestic purpose. There is a need to have quality water for domestic use to promote good human health (Ramesh & Elango, 2011). In the urban settlement, groundwater is vulnerable to adulteration from solid waste leaches, untreated sludge and manufacturing emissions that leak into the ground and thereby reaching water-bearing rock formations (Lapworth *et al.*, 2017). Water is not pure as it can dissolve, absorb, adsorb and acquire suspended impurities in it and this is attributed to its polarity and hydrogen bonds; and is found in two forms:- either as surface water or groundwater (Pitt *et al.*,1999).

Jeje & Oladepo (2014) pointed out that increasing heavy metal levels in water sources has attracted a lot of concern from researchers about the heavy metals toxicity to biota. The toxic nature of lead, cadmium, and mercury is a threat to human health. These metals are elements of the earth's crust however anthropogenic events such as septic tanks, mining activities, agricultural activities and industries contribute to enhanced levels of heavy metals in borehole waters (Gautam *et al.*, 2014).

Heavy metals are currently the most persistent water impurities with known detrimental effects on human health. Gautam *et al.* (2014) established that these heavy metals transpire in water as an outcome of improper disposal of industrial waste, electronic waste, municipal wastewater, landfill leachates, mining activities and natural geochemical weathering of rocks. Volatile and particulate metal compounds are carried from one place to another by wind. However, according to World Health Organization (2014) the concentration of these metals has greatly increased due to human activities.

Naturally, in water, cadmium is observed at the lower sediments and suspended particles (Friberg *et al.*, 1986). Cadmium may be found in water because of industrial waste disposal or the corrosion of galvanized pipes.The acidity or basicity of domestic water is expressed as pH (less than 7.0 acidic, more than 7.0 basic). The normal pH range for domestic or drinking water is from 6.5 to 8.5 (WHO, 2011; NSDWQ, 2007).

There is an increased likelihood of the building up of Cr in aquatic life. Chromium is commonly used in metallurgical processes; magnetic tapes; and paint manufacturing, cement, paper, rubber, a constituent of floor covering and among others. It's also used in making of wood preservatives. EPA reported that chromium has capability to cause many health effects when people are subjected to levels above the maximum contaminant level (MCL) for relatively short periods: dermatitis or ulceration. At levels above the MCL, chromium can result to lifetime defects for instance damage to the liver, kidney circulatory, and nerve tissues.

The study was designed to investigate the levels of heavy metals in borehole water in Hadejia and Atafi Districts (latitude 12^0 13' – 13^0 60'N and longitude 90 22' – 11'00E). Similar to any other urban settlement, Hadejia has its population increasing and exerting pressure on available amenities such as water.

The population in Hadejia relies on groundwater obtained from boreholes and as a result, there is a need to assess the quality of water.

MATERIALS AND METHODS

Sample Collection and Analysis

Groundwater samples for the analysis were collected from twenty five different sites monthly in September, October and November, 2022 around 10:00 – 12:00pm. All the samples were collected and treated in accordance with the (ASTM, 2004; APHA, 2005). The boreholes were allowed to flow for about 3 minutes before the water is collected. Cadmium, Chromium, Iron, Manganese and Lead were determined using atomic absorption spectrophotometry at the Central Laboratory, Bayero University Kano, Nigeria. The pH and TDS of the samples were determined on site using Hanna pH 210 microprocessor pH meter after and "Hatch 446600 model TDS meter respectively.

RESULTS AND DISCUSSION

The Groundwater Mean concentration values of Physico-chemical parameters of groundwater from the study area is presented in table 1.

pH

The pH values of water from the study area ranged between 5.8 and 6.5. The pH in all the sampling sites are within/below the WHO recommended range of 6.5 – 8.5. The results shows that pH of groundwater in most of the sites are slightly below the WHO, 2011and NSDWQ, 2007 allowable limit for drinking water. The groundwater samples studied is characterized as being slightly acidic. It was remarked that though pH 7.00 is the neutral, up to 9.2 may be tolerated, provided microbiological monitoring indicated no deterioration in bacteriological quality.

Total Dissolved Solids

TDS values ranges between 31.0 mg/L and 38.3 mg/L, from the results the concentration of TDS in all the sampling sites are widely lower than the maximum permissible limit of TDS of 500mg/dm^3. Higher TDS in groundwater may be due to groundwater pollution when waste waters from residential are discharged into pit, ponds enabling the waste to migrate down to the water table thereby increasing TDS values in groundwater. The result shows that the samples have values below the WHO recommended maximum permissible limit of 500 mg/L. The palatability of water with a TDS level of less than 600 mg/L is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1000 mg/L(Matthess, 1982).

Cadmium

Cadmium pollution is major as a result of fertilizers made from phosphate ores. It dissolves in water depending on acidity of the water; suspended cadmium may dissolve due to elevations in acidic conditions (Ros & Slooff, 1987). The Cadmium values of the borehole water in this study ranges between 0.00 to 0.04m g/L. It was observed that the Cadmium values obtained in all the sampling sites were found to be lower than the recommended values of 0.07mg/L set by (WHO, 2011and NSDWQ, 2007) indicating that there is no alarming concern of health effects by drinking the water from these sources.

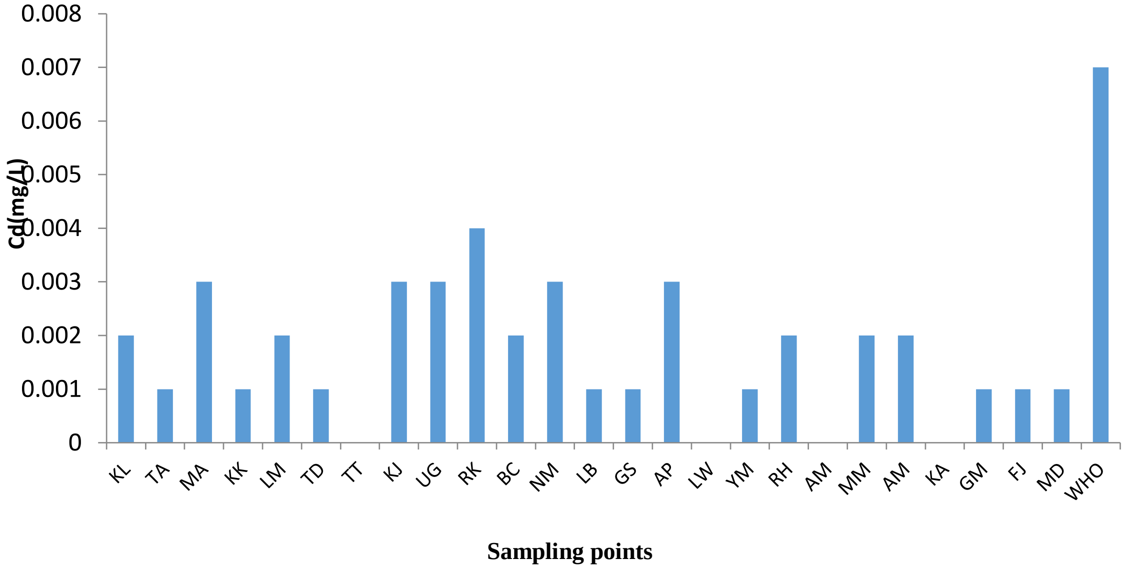

Figure 1: Frequency Distribution Pattern for Cd

Chromium

Cr is emitted to the surrounding through leakage, bad storage or inappropriate waste disposal ways. Tannery waste has been found to contaminate water. Major sources of Cr in drinking water are effluents from steel and pulp factories as well as degradation of natural deposits of Cr. Primary source of Chromium in water is usually from mining, water from electroplating operations, which is not a practice in the sites for this study, and garbage or refuse dump sites which is very much common in all the study areas. The Chromium values ranges between 0.243mg/L and 0.358mg/L. It was observed that the Chromium values obtained in all the sampling sites were found to be higher than the recommended values of 0.05 mg/L set by (WHO, 2011and NSDWQ, 2007). The higher values of Chromium could lead to the health implications among residents- within the sampling sites.

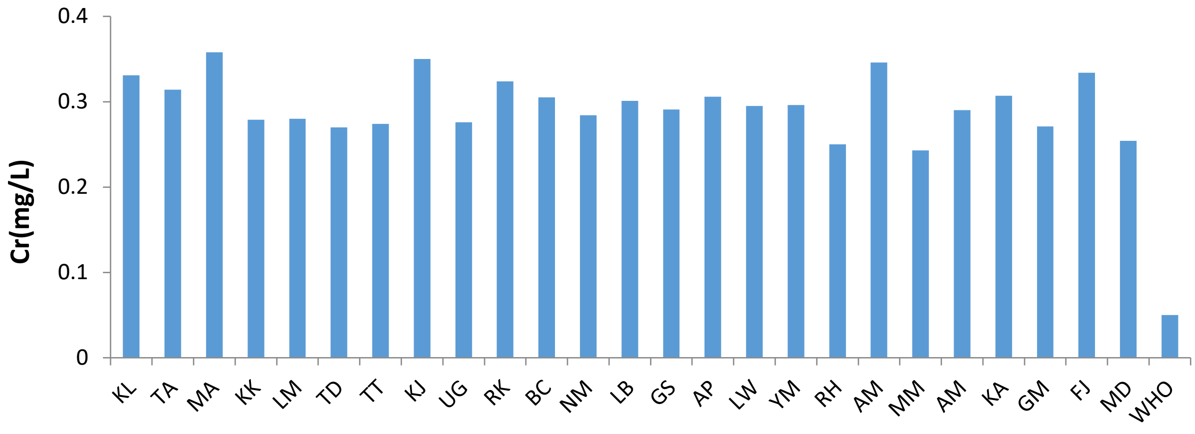

Figure 2: Frequency Distribution Pattern for Cr

Iron

Iron occurs in water in small quantity as iron bicarbonate. In groundwater, however, much higher levels of iron can occur. In anoxic ground waters with a pH of 6 to 8, ferrous iron concentrations can be as high as 50 mg/dm^3 and concentrations of 1.0 to 10mg/dm^3 are common (Mathias, 1992). Reduced groundwater is clear when first brought from a well but becomes cloudy, and then orange in colour, as oxidation occurs with the precipitation of ferric hydroxide. High iron concentrations in groundwater are reported from developing countries, where iron is often an important water quality issue. Iron concentration ranges between 0.967 mg/L and 1.359 mg/L. For this study, the iron levels in the water samples analyzed were above the WHO, 2011 and NSDWQ, 2007 recommended value of 0.3 mg/L. The higher Iron concentration is attributed to washing of some iron materials around the sampling points. Iron is not considered hazardous. In fact, instead it is an essential element for good health because it transports oxygen in the blood. Iron is considered a secondary or aesthetic contaminant. It was remarked that the form of goiter in adults was the result of consumption of water with quantity of iron above the specified values (Matthess, 1982).

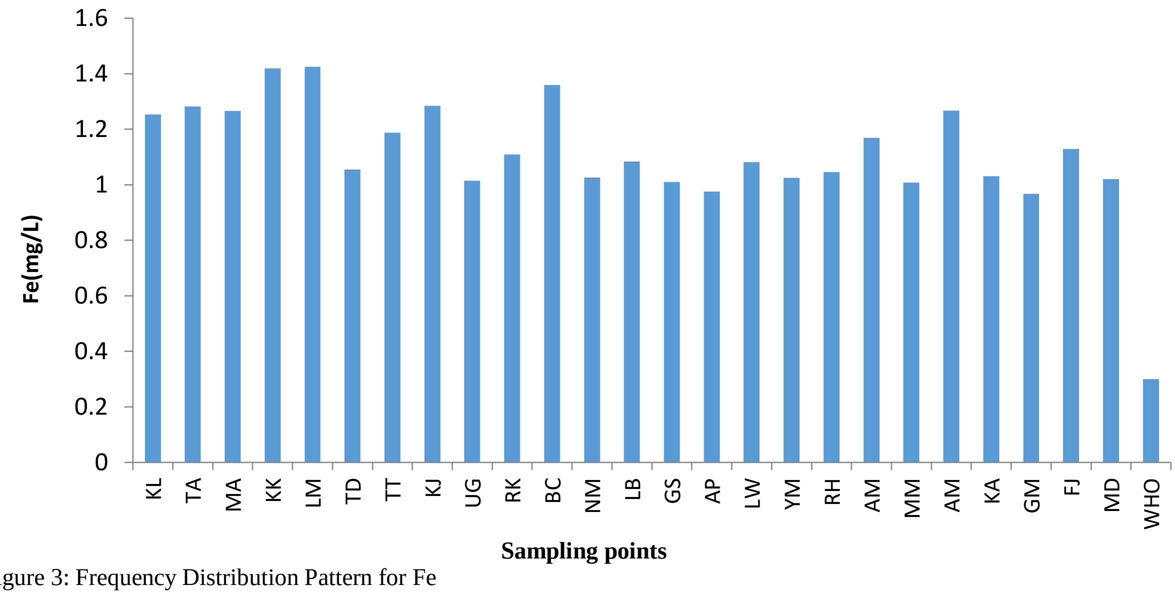

Figure 3: Frequency Distribution Pattern for Fe

Manganese

Manganese occurs in groundwater as divalent ion (Mn^{2+}) due to the lack of subsurface oxygen. The occurrence of manganese in public water supplies presents more of an economic problem than a potential health hazard. Manganese causes dark stains in laundry and on plumbing fixtures, tends to deposit in water lines, and impacts an objectionable taste to beverages such as coffee and tea (Matthess, 1982).

Manganese in natural waters rarely exceeds 1.0 mg/dm^3 but levels of 0.1 mg/dm^3 are sufficient to cause taste and staining problems. The maximum allowable manganese level in public water supplies is 0.05 mg/dm^3.

Manganese concentration obtained in the study areas ranged between 0.027 mg/L and 0.53 6 mg/L. Six samples constituting 24% of the total samples has Mn values above the recommended values of 0.05 mg/L set by WHO, 2011and NSDWQ, 2007; while nineteen (19) which constitute majority (76%) of the sampling points shows Mn values below the WHO recommended a value of 0.05mg/dm^3 which is still tolerable, but above this value will impair portability.

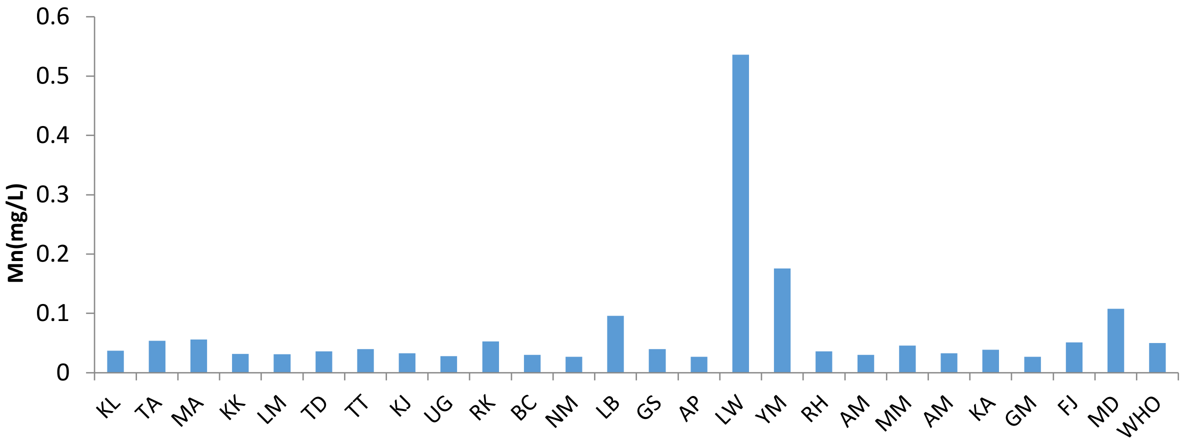

Figure 4: Frequency Distribution Pattern for Mn

Lead

Lead is seldom found in ground water in more than trace quantities and averages about 0.001 mg/dm^3 Natural water contains low levels due to its tendency to be precipitated by a large number of substances. The level of lead in public water supplies is usually low unless storage tanks have been painted with a lead – based paint or lead piping or fixtures have been used in the delivery system. Presence of lead in water may be from industrial, mine and smelter discharges or from the dissolution of old lead plumbing materials (APHA, 2005). Lead occurs in drinking water primarily from corrosion of Lead pipe and solders and faucets constructed with leaded brass, especially in areas of soft or acidic water. The values obtained ranged between 0.02 mg/L and 0.052 mg/L. It was observed that all the values were lower than the recommended values of 0.30mg/L Lead set by WHO, 2011and NSDWQ, 2007.

Higher concentration of Lead above the permissible limit is a clear indication of the danger posed to consumers if the water is used. Lead must not be more than 0.1 mg/dm^3 as the water becomes poisonous if present in higher concentration. These values were lower than the desired concentrations for domestic water consumption, hence it is fit for use as potable water.

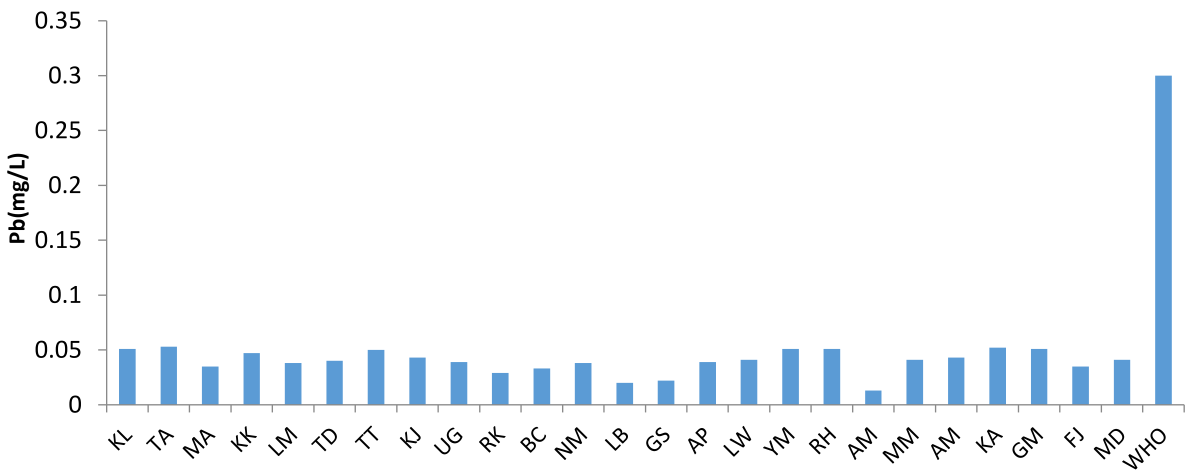

Figure 5: Frequency Distribution Pattern for Pb

CONCLUSION

There is a growing concern about the dangerous health implication of hexavalent chromium consumption in drinking water. It can cause skin and eye irritation, asthma, nasal ulcers, convulsions, acute gastroenteritis, and damage to the liver and kidneys. High iron in water content leads to an overload which can cause diabetes, hemochromatosis, stomach problem, and nausea; it can also damage the liver, pancreas, and heart. The results showed that concentrations of Cr (0243 – 0.358mg/L), and Fe (0.967 – 1.359mg/L) were found to be above the maximum permissible limit of Nigerian Standard for Drinking Water Quality and World Health Organization, Further study is necessary to clarify the origin, the mode of action, and the negative impact has on human, to create appropriate preventive and intervention measures.

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Table 1: Groundwater Mean concentration values

S/N	LOCATION	CODE	OWNERSHIP	pH	TDS	Cd	Cr	Fe	Mn	Pb
1	KOFAR LIMAN	KL	INDIVIDUAL	6.0	32.8	0.002	0.331	1.253	0.037	0.051
2	TITIN ATIKU	TA	INDIVIDUAL	5.9	33.9	0.001	0.314	1.282	0.054	0.053
3	MAKWALLA A	MA	GOVERNMENT	6.3	34.8	0.003	0.358	1.266	0.056	0.035
4	K/KOFA	KK	GOVERNMENT	6.0	36.8	0.001	0.279	1.419	0.032	0.047
5	LOKON MALAMAI	LM	GOVERNMENT	6.0	37.3	0.002	0.280	1.425	0.031	0.038
6	TITIN DUBANTU	TD	INDIVIDUAL	6.0	36.2	0.001	0.270	1.055	0.036	0.040
7	TUDUN TANDA	TT	INDIVIDUAL	6.0	36.0	NA	0274	1.188	0.040	0.050
8	K/KUDA JUNCTION	KJ	GOVERNMENT	6.3	34.3	0.003	0.350	1.285	0.033	0.043
9	UNGUWAR GOJE	UG	INDIVIDUAL	6.1	34.4	0.003	0.276	1.015	0.028	0.039
10	RIJIYAR ALI KATAKU	RK	GOVERNMENT	6.0	35.6	0.004	0.324	1.109	0.053	0.029
11	OPPITE BASH COMP. CENTER	BC	GOVERNMENT	6.2	37.3	0.002	0.305	1.359	0.030	0.033
12	NASARAWA MOSQUE	NM	INDIVIDUAL	6.4	36.9	0.003	0.284	1.026	0.027	0.038
13	LAYIN USMAN BN AFFAN	LB	INDIVIDUAL	5.8	35.6	0.001	0.301	1.084	0.096	0.020
14	GAMBO SALEH MOSQUE	GS	INDIVIDUAL	5.8	36.2	0.001	0.291	1.010	0.040	0.022
15	ATAFI PRIMARY	AP	INDIVIDUAL	5.8	37.3	0.003	0.306	0.975	0.027	0.039
16	LAYIN S/WANZAMAI	LW	GOVERNMENT	5.9	35.8	NA	0.295	1.082	0.536	0.041
17	YANKOLI B/MASALLACHI	YM	INDIVIDUAL	5.9	36.3	0.001	0.296	1.025	0.176	0.051

18	RAMIN HUDU	RH	INDIVIDUAL	6.1	31.8	0.002	0.250	1.046	0.036	0.051
19	NEAR ABBAS MAGANI	AM	GOVERNMENT	6.3	36.4	NA	0.346	1.169	0.030	0.013
20	MATSARO MOSQUE	MM	INDIVIDUAL	5.9	36.3	0.002	0.243	1.008	0.046	0.041
21	MAL. AKILU MOSQUE	AM	GOVERNMENT	6.4	30.8	0.002	0.290	1.267	0.033	0.043
22	G/MARI-KURMA ABAGA	KA	INDIVIDUAL	6.1	38.3	NA	0.307	1.031	0.039	0.052
23	G/MARI-MAL.GANA SHOP	GM	GOVERNMENT	6.5	36.3	0.001	0.271	0.967	0.027	0.051
24	G/MARU-FILM JOMO	FJ	GOVERNMENT	6.0	31.1	0.001	0.334	1.129	0.051	0.035
25	MAJEMA-MAIUNGUWA DUKAWA	MD	GOVERNMENT	6.1	31.0	0.001	0.254	1.020	0.108	0.041
	WHO			8.5	500	0.007	0.05	0.30	0.05	0.30