Quality Analyses of Some Common Salts Produced in Ghana

Asamoah, D. N. and Dzigbodi-Adjimah, K.
Geological Engineering Department,
University of Mines and Technology,
Tarkwa, Ghana

Abstract

This study presents and discusses the results of chemical analyses of the quality of selected salt samples produced in Ghana. With the exception of the Daboya salt producing areas in northern Ghana, the samples were collected from the seven major centres of salt production along the coast of Ghana from Axim to Keta. Five of the samples are from local salt producers whilst the remaining two samples are from the two salt factories namely, Panbros and Songhor salt factories. Two sets of samples were collected from each location during the rainny season and the dry season to account for seasonal variations. The Samples were then composited and taken as a representative sample from the location.

The analyes were carried out the Ghana Atomic Energy Comission, Accra. The physicochemical parameters determined included pH, electrical conductivity and total dissolved solids. The metal and anions contents consisted of K, Na, Ca, Mg, Fe, Cu, Pb, As, Hg, Cd, SO_4, I and Br. Generally the salts do not appear to meet the standard specifications of common salt by the Ghana Standard Board. They are generally low in Na, K, Ca and Mg. The Ca content ranging from 67.78 $mgkg^{-1}$ to 228.94 $mgkg^{-1}$ whilst Mg ranges from 24.03 to 41.61 $mgkg^{-1}$ compared with the recommended value of 2000 $mgkg^{-1}$ by The Ghana Standards Board(GSB).

Fe, and Cu content of the salts is quite high but Pb, AS and Hg are low and refreshingly well below the recommended threshold values. Fe concentration varies from 5.88 to 18.56 $mgkg^{-1}$. Salt from the Songhor factory showed higher concentration values above the GSB levels as all the other salt samples showed values below the GSB value of 10 $mgkg^{-1}$. The high Fe content may be attributable to contamination from ferruginous underlying bedrocks like Elmina sandstones and Togo and Buem sandstones, quartzites and shales. Apart from Keta salt, all the other salt samples had Cu concentrations above GSB permissible limit of 5 $mgkg^{-}$

The analysis of the trace metals revealed high levels of Cd,with all the samples showing Cd concentration excess of the recommended 0.5 $mgkg^{-1}$ (maximum of GSB) [1].

Approximately 40 % of the salt samples have SO_4 concentrations exceeding the GSB maximum limit of 14000 $mgkg^{-1}$ for edible salt.

The study recommeds that salt ponds may be lined to reduce contamination and that salt produced by the traditional and artisanaal methods be purified before use.

I Introduction

Common salt or sodium chloride is a white mineral that is of great importance to chemical industry and humans as food supplements to support physiological functions. Salt is an excellent carrier of iodine, which is used at recommended levels to prevent goitre and cretinism. The main uses of salt in industry, agriculture and domestic consumption are:

- The chloalkali industry converts salt mainly into chlorine, caustic and soda ash which are used in petroleum refining, petrochemistry, organic synthesis, glass production.
- In agriculture, salt is used as food supplement for live-stock.
- In the food indusry salt is used as seasoning, preservative and canning of vegetables and fish as it inhibits the growth of bacteria, which would lead to spoilage of the product. It is also added to control the rate of fermentation in bread dough.
- In petroleum exploration, salt is an important component of drilling fluids in well drilling (Saltwater Mud).
- In industry it is used in photography, hardning of leather industry, grease and oil purification, cotton print, enameling, metallurgy, and the regeneration of ion exchange resins.
- Salt is also used to prepare medicaments, physiological solutions, tooth pastes and gargles, in solutions for cleaning wounds. In the temperate countries salt is used in de-icing of roads in winter.

Commercial and residential water-softening units use salt to remove ions causing hardness of water.

However, salt has some impurities, such as Al, Ba, Fl, Fe, N, P, Si, Sn, Cd, and the heavy metals like Cr, Cu, Mn, Mo, Ni, V which if not controlled quantities, could cause serious industrial and health hazards. For example, for the chemical industry which especially uses salt as feedstock in the chloralkali industry, particularly in the electrolysis using ion exchange membranes, elements could have disastrous effects on production if their content in salt exceeds some limits and for human consumption, elements such as As, Hg, Pb are poisonous. The content of such elements in salt should therefore be assessed before usage. Impurities increase the cost of brine treatment in chloralkali plants, magnify the problems of contaminated effluent disposal and necessitate costly refining of salt for human consumption.

The global situation is not very different from that of most African countries including Ghana where most of the salt is locally produced. For example Ca content in Ghanaian salts has been found to be in the range of 0.1 & to as high as 0.56 % (Owusu, 1971; Mensah & Bayitse, 2005). Since most of the salt used in Ghana is produced locally and there are several diferent types of the salt on the Ghanaian market and the quality of the salt depends on how it is produced it is very necessary to critically assess the quality of the salt and the processes by which it is processed.

The situation is, however complicated by the different types of salt that are produced in Ghana. Since the quality of depends on the method of production, it is important to review the various methods of salt production in Ghana to see how the production affects the quality recommending appropiate treatment measures. This paper therefore examines the nature of impurities in salt produced in Ghana by appraising the quality of salts from 6 production sites and compare them with the standard specifications of the Ghana Standard Board.

2 Salt Production In Ghana

2.1 Types of Ghanaian Salts

Four types of solar salt production are recognised in Ghana:

a. Stoved salt process
b. Artisanal Salt winning from lagoons during the dry season
c. Traditional Solar salt Production on small scale
d. Modern Solar salt Production on large scale

The locations, methods of production, quality quantity of the various Ghanaian salts are summarised in Table 1

Table 1: Types of Salt in Ghana: The Quantity, Quality and Methods of Production

Salt Type/ (References	**Locality & Rock Type**	**Source Material**	**Method**	**Quality of Salt in g/l**	**COMMENTS/REMARKS**
STOVED TYPE (Daboya Type) (Bates, 1953)	Daboya, Tibogona from Voltaian Sedimentary Rocks in Northern Ghana	Brine Solution from White Volta bed	Heating on fire of brine solution	0.73 % NaCl, impurities include gypsum & anhydrite	Produces 4-6 % of Ghanaian salt and not a very significant source of salt in Ghana
TRADITIONAL TYPE Ada Type (Quarshie & Oppong, 2006) Mensah and Bayitse, (2006)	Songhor (Ada), Prampram, Keta Nyaunyanu. Togo Series rocks,	Sea water from dug-out wells	Solar evaporation of seawater from dug out wells	90 % NaCl, Contains all dissolved chemical compouds in seawater. Mixture of $CaSO_4$, $MgCl_2$, KCl, Fe_2O_3, sand, clay content	Produces about 20 % of Ghana'salt. High percentage of Ghana's salt is produced by this Traditional method and therefore needs proper analytical studies to ensure the safety of consumers.

				from 0.1 % to 0.56 % .	
ARTISANAL TYPE (Ada Type) (Quarshie & Oppong, 2006)	Elmina, Songhor, Keta, Clay and silt, Elmina sandstones, Accraian shales & sandstones	Lagoonal waters Back waters from embackments built at the junction of the sea and lagoonal waters. Sea water is allowed to flow (under gravity) or is pumped out.	Large coastal lagoons.Sea water flows under gravity or is pumped through series of gates created. Heating by steam pipes or boilers (stove Salt) and solar evaporation methods.	60 % NaCl, contains all the chemical impurities of sea water 60 % NaCl high Mg content giving it taste bitter.	Produces about 51 % of the country's salt is by this method. This type of salt is more patronised and therefore much attention needs to be focused on this type of salt to save consumers.
MODERN SOLAR TYPE (Factory Salt) Panbro & Songhor	Accra, Songhor Lagoon Accraian Accaian Devonian sandstones	sea water)concentrates in salt ponds	Fractional crystallisation of seawater through concentrators. Bitterns are recycled into	90% NaCl, Salt contains high levels of Mg	Produces about 20 % of the Ghana's salt

(Quarshie & Oppong, 2006), Mensah & Bayitse, (2006)	& shales		fresh brine for salt re-production	0.98%	

From Table 1 it is seeen that the Daboya type salt production contributes only 4 to 6 % of salt produced in Ghana. Although it is a major source for the people of Northern Ghana its influence is very localised.

About 20 % of the salt in Ghana are from the two salt factories namely, Panbros in Accra and Songhor at Ada.

Over 70 % of the salt used in Ghana comes from the traditional and Artisanal productions. It is seen that NaCl content of the Artinasanal salt which is the most used (51 %) is only 60 % NaCl. Both methods have the highest impurities in their salts as most of the impurities in the seawater are found in these salts. In addition the Artisanal salt is bitter in taste which needs to be treated to give it a better taste. For this reason the present study focuses on these latter groups of salt production in order properly assess the quality and suggest ways by which it could be improved.

Figure 1 illustrates the coastal map of Ghana where majority of Ghanaian salt are produced. Sample locations cut accross all the types of methods of salt production in Ghana demonstrates the different localities. Sampling was done at all the salt producing areas along the coast of Ghana from half Assini to Keta from locations. Because of logigistic limitation and on acoount of the low volume of salt produced fron the Northen Ghana (4%) the Daboya type was not sampled.

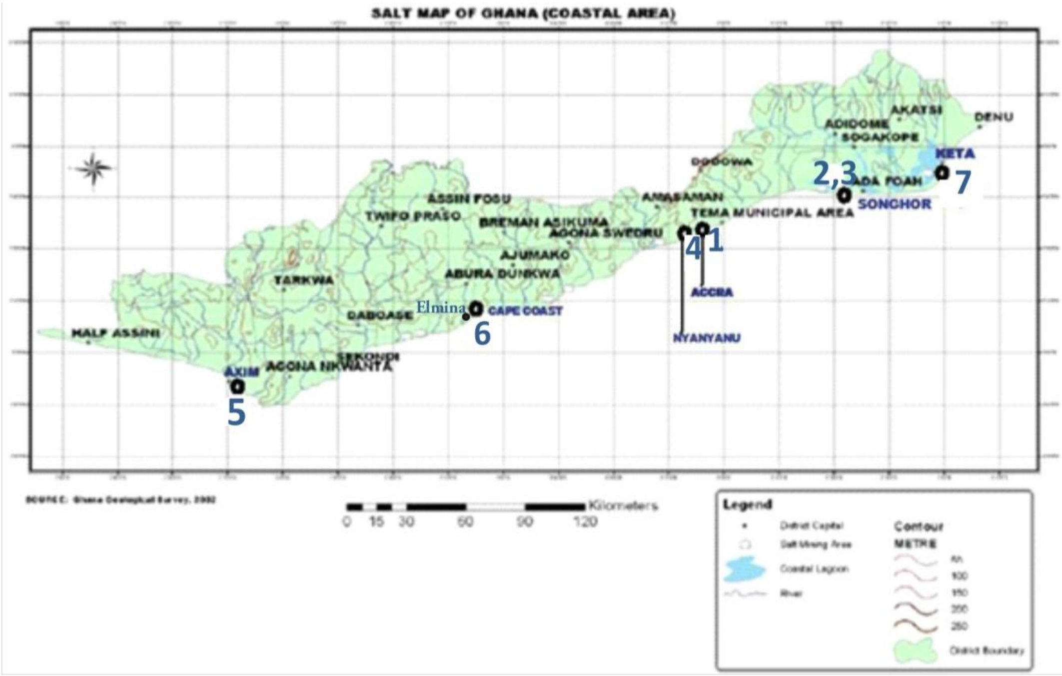

Fig. 1 Coastal Map of Ghana showing salt producing areas where samples for the study were collected.

3.0 Data Acquisition and Analysis

3.1 Sampling:

In order to get representative samples of salt from all the salt producing areas in Ghana**,** the sampling exercise was carried out from along the entire coastline from Half Assini to Keta as Shown in Fig. 1.

At each location a kilo of salt was procured from at least 10 different producers. These were composited, quartered and about a kiologram weight of the composite was taken as a representative sample of the locality. The limited number of two samples from salt factories the quality of the salt is uniform which in contrast to the artisanal, traditional and stoved type salt are from different producers who may not produce the same quality of salt. Two samples are taken factory salts each from the major and minor seasons.

Because of seasonal variations in the quality of source materials e.g. ground water. Brine solutions and sea water that used in salt production and since this has a bearing on the quality of the salt produced in an area it was decided to sample each location two times during the year. The first sampling was carried out immediately after the dry season in January and the second one at the end of the rainny season in September

Table 2: Salt Samples used in the Present Study

Sample No	**Type of salt**	**Sample Locations**	**No of samples**
Sample 1	Factory Type	Panbros	2
Sample 2	Factory Type	Songhor (factory)	2
Sample 3	Traditional	Songhor (local)	10
Sample 4	Artisanal	Nyanyanu	5
Sample 5	Stove	Axim	6
Sample 6	Artisanal	Elmina	7
Sample 7	Traditional	Keta	10
Sample No	**Type of salt**	**Sample Locations**	**No of samples**
Sample 1	Factory Type	Panbros	2
Sample 2	Factory Type	Songhor (factory)	2
Sample 3	Traditional	Songhor (local)	10
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Sample 5	Stove	Axim	6
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		(factory)	
Sample 3	Traditional	Songhor (local)	10
Sample 4	Artisanal	Nyanyanu	5
Sample 5	Stove	Axim	6
Sample 6	Artisanal	Elmina	7
Sample 7	Traditional	Keta	10

3.2 Analysis

The salt samples were analysed using the Atomic Absorption Spectrophotometer (AAS) at the Ghana Atomic Eenergy Commission (National Nuclear Research Institute-NRI) for heavy metals (Fe, Cu, Pb, Cd, Ca, Mg). The Hach DR / 890 with appropiate reagents as described in the DR/890 Datalogging Colorimetre Handbook (Anon., 1999) was employed to test for sulphates.

4.0 Results

The values presented in Table 4 are for analyses of the composite samples from each locality. The recommended figure from Ghana Standard Board (GSB) are presented in column 8.

Table 4. Analysis of chemical constituents of common salt in mg/kg

Elements	Factory1 Panbros	Factory 2 Songhor	Traditional 1 Keta	Traditional 2 Ada	Artisanal 1 Elmina	Artisanal 2 Nyanyanu	Stove Type Axim	GSB
K	57 300	54 000	81 000	115 000	63 000	72 000	81 000	NA
Na	915 000	870 000	993 000	800 000	960 000	894 000	699 000	**970 000**
Ca	228.94	159.34	219.13	208.34	67.78	147.14	208.34	**2000**
Mg	39.44	24.99	24.03	30.54	32.38	33.08	41.61	**1000**
Fe	5.88	10.96	18.56	1.86	6.00	8.16	10.34	**10**
Cu	6.56	6.34	6.84	2.8	6.72	6.88	7.16	**2**
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**2**
As	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	**0.5**

Hg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	**0.1**
Cd	2.00	2.28	2.44	0.80	2.00	1.64	1.32	**0.5**
SO_4	3415.38	2584.62	6599.99	29384.61	14861.54	3646.15	30276.92	**5000**
I	127.81	71.42	105.81	69.57	100.24	142.29	9.28	**NA**
Br	223.09	51.09	242.84	1513	378.13	81.59	653.49	NA

From the chemical analysis of the salt samples, results are presented in Table 4. The major and trace constituents are given in graphical representatations for easy identification Fig. 2 - Fig 14. With the aid of the graphs these constituents are discussed.

The major constituents are K^+, $Ca^{2+,}$ Mg^{2+}, Na^+, and the rest of the constituents trace Table 4.

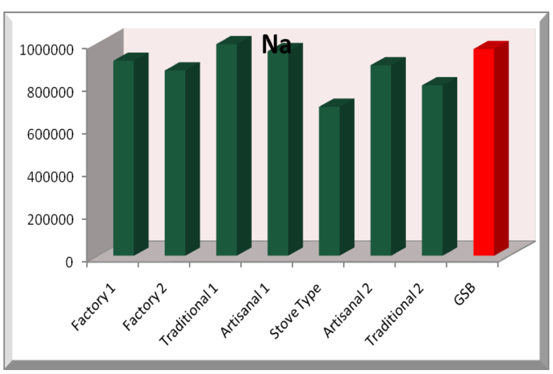


Fig. 2 Na content in Ghanaian salt samples

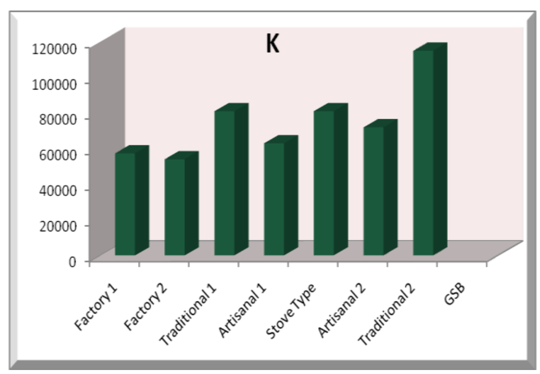
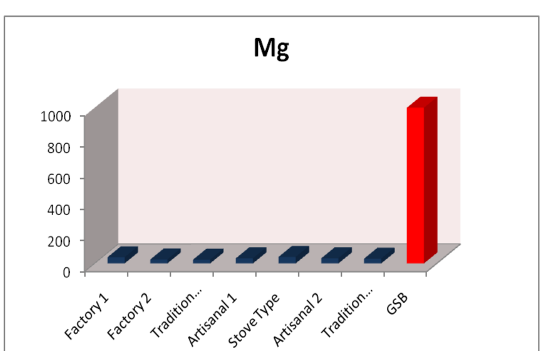


Fig. 3 K content in the salt samples



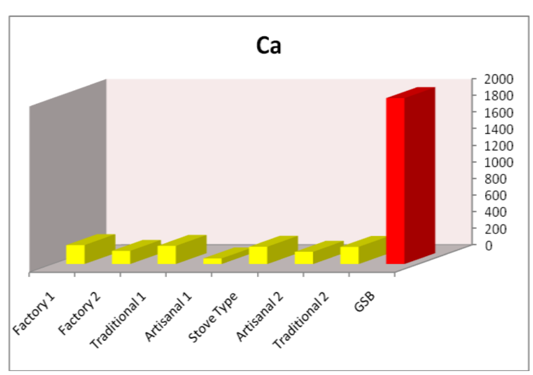


Fig. 4 Calcium content in salt samples

Fig. 5 Magnesium content in salt samples

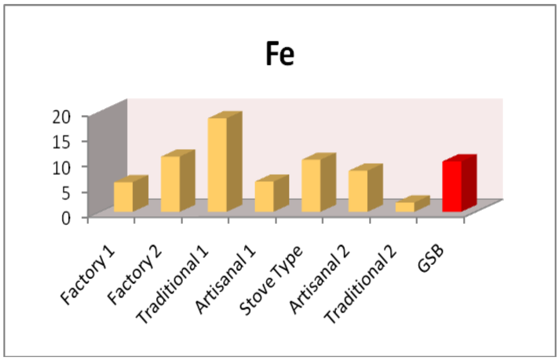


Fig.6 Iron content in the salt samples

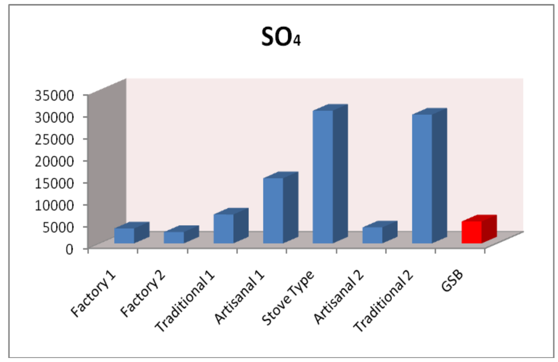


Fig.7 Sulphate content in salt samples

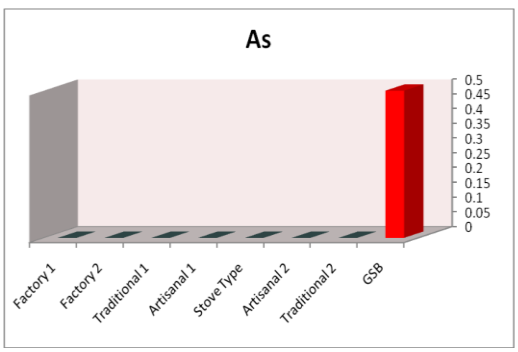


Fig. 8 Arsenic content in salt samples

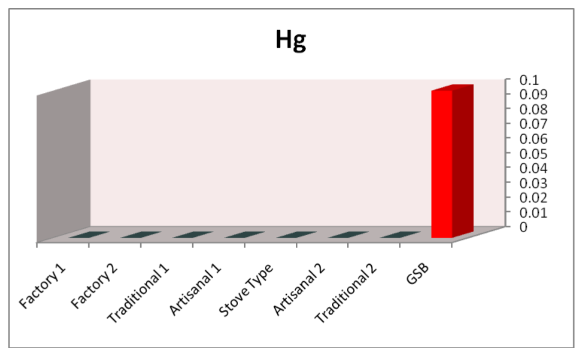


Fig. 9 Mercury content in salt samples

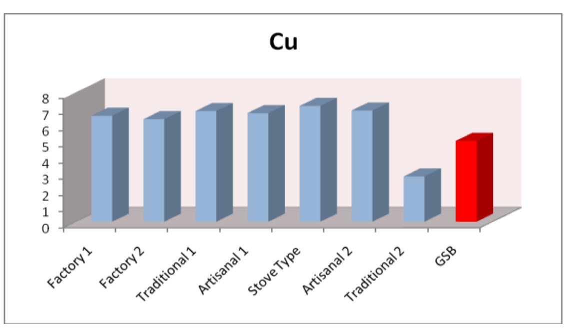


Fig.10 Copper content in salt samples

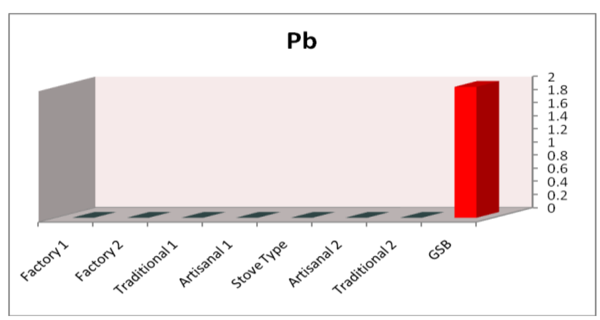
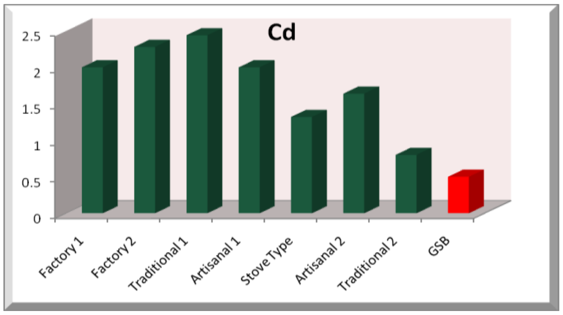


Fig.11 Lead content in salt samples



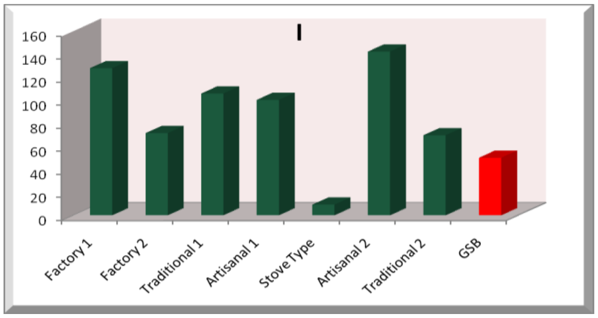


Fig. 12 Cadmium content in salt samples **Fig.13 Iodine content in salt samples**

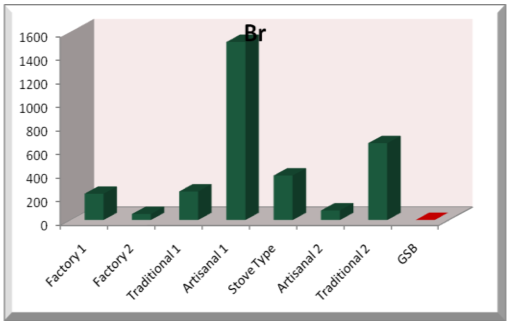


Fig. 14 Bromine content in salt samples

4.0 Discussions

From Table 4, it is seen that the constituents of the various salts produced in Ghana do not quite meet the specifications of standards Board. In the following discussion, the major constituents are taken in turnand their cocentrations in each of the salt type considered

4.1 Major constituents

Na, K, Ca, Mg, Fe and SO_4 are the major constituents in Ghanaian salts their concentrations as compared to the Ghana standards Board specifications are seen in Fig 2 to Fig 7.

4.1.1 Na and K

From Fig 2 it is seen that all that all salt produced in Ghana except the traditional salt from Keta fall short of the recommended GSB level of 970000 $mgkg^{-1}$. Since people on low-Na salts diets have more than four times as many heart attacks as those on normal-sodium diets (Anon. 2010), the low content of Na in the salts must be cause of concern hence steps should be taken to increase the Na content of the salts.

On the contrary the K content in Ghanaian salts appears quite high ranging from 115 000 $mgkg^{-1}$ from the traditional producers to a low of 57 300 $mgkg^{-1}$ in the Factory types (Fig 3). Unfortunately the values of GSB was not available for comparison.

4.1.2 Ca

From Fig. 4, it is observed that the Ca content in the salt samples ranges from 67.78 to 228.94 $mgkg^{-1}$which are all below the GSB maximum requirement of 20000 $mgkg^{-1}$. The lowest Ca level was established from artisanal salt production and the highest value was obtained from a factory salt production. The low Ca content is also a sign od worry because Ca is essential for building and maintaining healthy bones, muscle contraction and blood clotting mechanism and for building healthy teeth. A calcium deficiency in the body causes restlessness and wakefulness.

4.1.3 Mg

Similarly Fig 5 illustrates that the Mg concentrations in all the salt samples which range from 24.03(from the traditional type) to 41.61 $mgkg^{-1}$ (in the stove type salt) are much lower than the GSB value of 1000 $mgkg^{-1}$. Since Mg plays an important roles in the structure and function of the human body and Ca and Mg produce calming effects on the brain and the lack of these elements may cause leg cramps during the night (Anon., 2010b). The observed low Mg contents should be a source of concern.

4.1.4 Fe

From the results, it is evident that salts with the highest Fe concentrations in Ghana are those produced from the Songhor Lagoon (Fig . 6). The Fe content varies from 5.88 $mgkg^{-1}$ at the factory to 18.56 $mgkg^{-1}$ from the traditional producers at keta, Axim ana Songhor lagoon compared with the recommended GSB values of 10 $mgkg^{-1}$. Though Fe is required in the body to produce hemoglobenas Fe, along with Cu, helps in the formation of red blood cells and helps to prevent fatique, dizziness, headaches, etc. Excess Fe may cause brown colouration of salt and decrease its aesthetic value. of the salt. The high iron content of salts from this locality may be due to the ferruginous content of the underlying country rocks of the area. These are sandstones, quartzites and shales of the Togo and Buem rocks. It is unclear whether the Fe contamination occurs in the crystallisation ponds or during the flow of rivers and stream that drain into the Lagoon. If it is the first case then lining of the floors of the ponds to prevent contact with the underlying rocks may be a solution. However if it is the streams and rivers that are contaminanted, then purification of the salt after crystallisation may be useful.

4.1.5 SO_4

From Fig. 7 it is observed that the sulphate content of three samples namely, Panbros and Songhor factories and an artisanal (Elmina) types are all within the permissible limit of 5 000 $mgkg^{-1}$ with the Songhor factory recording the lowest level of 2584.62 $mgkg^{-1}$. Two samples from Keta and Axim however produced sa lts with high sulphate contents of 29 384.61 and 30 276.92 $mgkg^{-1}$ respectively which needed to be addressed

4.2 Trace Elements

The trace elements in the analsed salt samples include Cd, Cu, Pb, As. I and Br

4.2.1 Cadmium

Cd content in Ghanaian salts is quite high ranging from 0.8 to 2.44 $mgkg^{-1}$ which is much higher than the GSB speciications of 0.5 $mgkg^{-1}$ (Fig. 8). Incidentally the salts from Songhor and Panbros salt factories have the highest concentrations of Cd contaminations. Human uptake of cadmium above the GSB threshold can cause diarrhoea, stomach pains and severe vomiting hence the incidence of the high Cd content must be addressed.

4.2.2 Copper

The recommended GSB value of Cu in edible salt is 5 $mgkg^{-1}$. However in Fig. 10 it is seen that thesalt from Axim contains as much as Cu 7.16 $mgkg^{-1}$. Though Cu is necessary in the human system. Normally lack of Cu may lead to anemia and osteoporosis, howver, too much cu can cause health problems as long-term exposure to copper can cause irritation of the nose, mouth and eyes and it causes headaches, stomaches, dizziness, vomiting and diarrhoea. High intakes of

Cu may cause liver and kidney damage and even death so that Cu content of salt should be properly monitored (Smedley *et al.*, 1995).

4.2.3 Lead, Arsenic and Mercury

Figs. 8, 9, 11 respectively show the contents of Pb As, and Hg in the samples. The figures show that the contents of these elements in Ghanaian salts are well below the GSB values that could cause health problems for consummers. It is rather heart-warming that all Ghanaian salts are free of Pb hence there is no anxiety of lead poising from consuming salt produced from Ghana.

4.2.4 Iodine and Bromine

Figs 13 and 14 show levels of odine and Br contents of the at various salts. Iodine ranges between 9.8 and 142.29 mgkg^{-1}.whilst Br is between 51.09 and 1513 mgkg^{-1} . All the salt type samples ,except The Stove type from Axim , contain Iodine concentrations above the threshold value of 50 mgkg^{-1}. Iodine prevents goitre hence it is necessary that salt from the Axim area be iodised before being put up for human consumption.

5.0 Conclusion

It may be concluded from the present investigations that:

1. The Content of major elements such as Na, K. Mg and Ca of Ghanaian salts is generally low, for example, the mean value of NaCl in the salts is 87.59% which is much lower than the required 97% NaCl of the Ghana Standars Board.
   It could thus be concluded that the quality of thesalts investigated in this study area do not conform to the Ghana Standard's specification for salt.

2. The major contaminants are high Fe,Cd and cadmium content of 2.44 mgkg^{-1} from Songhor (local) traditional site with the lower value of 0.80 mgkg^{-1} from salt being produced from

3. Keta salt has lthe lowest contnt of Cdof 0.80mg/kg

significant highFe concentrations of iron in the salt samples. The iron concentrations vary from 1.86-18.56 mgkg^{-1} as against GSB values of 10 mgkg^{-1}. Three production areas, Songhor

Songhor factory and local, Keta, Axim have samples all giving higher values above the GSB specification.

Though the permissible limits of sulphates in common salt is 5 000 $mgkg^{-1}$, samples showed high sulphate content up to 29 384.61 $mgkg^{-1}$ which should be addressed.

Three samples produced from Panbros Factory, Songhor (local) and Keta have lower sulphate concentrations below the GSB specification.

In order to reduce the level of contaminants and increase quality of salt produced in Ghana to acceptable limits, the processing methods must be improved to eliminate sources of contamination such as lining of the salt ponds and the recycling of bittern in the traditional process. The salt could be washed and purified before consumption.

References

Anon., 2010a http://www.shirleys-wellness-cafe.com/salt.htm#115/07/10

Anon., 2010 http://www.natural-health-information-centre.com/potassium.html 5/24/2010

Anon., 2010b http://www.minniepauz.com/calcium.html

Bates, D.A. 1953. "Salt water from Tamale borehole". *Annual Report of the Director of Geological Survey* for 1951-1952 7p

GS 12 (1993) *Spices and Condiments-Specification for Unrefined Edible Salt.* Ghana Standards Board, Accra, Ghana.

Mensah, B. & Bayitse, R., (2006), Solar Salt Technology in Ghana – 'A Case Study of Small Scale Saltwinning Process' *Ghana J.* Sci. Volume 46, 99-109pp. CSIR – Institute of Industrial Research, Accra, Ghana

Merlot, A. G. (1993), Solar Salt Technology. (P. C. Acquah ed.) Minerals Commission, Accra, Ghana 11-18pp

OWUSU, A. A. ,(1971) Sodium Chloride: Production,Quality and Possible Uses of Common Salt in Ghana. Technical Report, CSIR-Industrial Research Institute-Ghana

Quaye, J. A., Boamah, D., Amoako, P. Y. O. (2008), Ghana's White Gold – Critical Issues Ghana Geological Survey Department, Accra, Ghana 139pp.

Quashie, A. and Oppong, D., (2006), 'Ghanaian Solar Saltworks: Promoting and Protecting the Ecology', Proceedings of the 1st International Conference on the Ecological Importance of Solar Saltworks (CEISSA 06) Santorini Island, Greece, 20-22pp.

Smedley L., Ednunds, W. M., West J. M., Gardner S. J. and Pelig-BA K. B. (1995). Vulnerability of Shallow Groundwater Quality due to Natural Geochemical Environment. Health problems related to Groundwater in the Obuasi and Bolgatanga Areas, Ghana.

World Health Organisation (WHO) (1980). Recommended health-based limits in occupational exposure to trace metals. *Technical Report Series, No. 647*. Vienna, Austria.*Report Prepared for ODA under the ODA/BGS Technology Development and Research Programme, Project 92/5.*