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Economic Potential of Salt Mining in Ghana Towards the Oil Find

M. Affam and D.N. Asamoah
Geological Engineering Department, University of Mines and Technology,
Tarkwa, Ghana

Abstract: The objective of this research is to give an overview of Ghana's salt industry and how the industry can maximize from the oil find through increased salt production and value addition. Ghana is endowed with commercial quantities of common salt, which have not been fully exploited to effectively contribute to the country's economic growth. With the discovery of oil in commercial quantities, currently in excess of 300 million barrels of recoverable crude oil, the prospect for the salt industry to grow is keener. From the four or more methods available for salt production, solar techniques involving both modern and traditional methods appear to be widely used in Ghana as a result of favourable climatic conditions. Out of the production potential of between 2 to 3 million tonnes per annum, just about 10% (about 250,000 tonnes) is produced annually. The quality of salt was examined by sampling all the production locations along the over 500 km coast line. Test results showed that some impurity levels were high. Concentrations of copper and cadmium levels were fund to exceed recommended threshold levels. This study calls for improvements in the current salt production system and diversification into value addition to broaden the benefits of Ghana's oil find.

Key words: Chloro-alkali industry, mordern solar-salt, traditional solar-salt, value-addition

INTRODUCTION

Common salt, (Halite-NaCl) is an important economic mineral that is widely distributed on all the continents and occurs in large reserves. It is among the five major chemicals which form the backbone of the chemical industry including petroleum (Anonymous, 2010; Feldman, 2005). It plays a critical role in the chloro-alkali industry and it is used by both animals and humans in their diets (Livingston, 2005). Ghana and Senegal are the only countries with the most favourable coastlines for salt winning in the West African sub-region, however, this advantage has not been exploited. Total production from these two countries remains low and continues to dwindle. Of the two countries Ghana has the best potential. Ghana's total Ghana has a potential solar salt production base for establishing a regional plant to produce basic chemicals such as caustic soda, chlorine, hydrogen, petrochemicals and other related products.

Apart from bedded or fossil salt domes (Kesse, 1985) the most common source of salt production (mining) is from salt winning by evaporation of sea water. The production of salt by solar evaporation is the main method used in Ghana. Apart from the artisan salt winning method in which there is virtually no intervention by man in terms of construction of embankments, other methods involve the construction of dykes and the use of pumps to control the flow of water .Some of the mining technique is rudimentary and it usage by most of the artisanal salt winners does not help in producing substantial quantities of salt that can earn sufficient income for the country (Quashie and Oppong, 2006).

Salt production is mainly found in the coastal region and production is far below the average expected demand of 2.5 million metric tonnes per year. It is estimated that the productivity of salt works in Ghana averages 1,600 ton/year/ha of crystallising area on the climatic factors (Anonymous, 2008). However salt winning is rudimentary and burdened with problems in Ghana. In Ghana salt winning is concentrated predominantly in the Central, Volta and Greater Accra Regions where climatic conditions are most favourable. (Anonymous, 2004a) Area such as the Keta Lagoon, the Songor Lagoon, the Densu Delta area, Nyanya lagoon, Oyibi lagoon, Amisa lagoon and Amwin/Benyah lagoon are the dominant mining zones

This study gives an overview of the salt industry in Ghana, presents a market analysis, outlines the problems facing the salt industry, discuss these issues with case studies from similar tropical countries, present proposals for improving the salt industry in Ghana. It also propagates the need to establish a chloro-alkali industry in the West African sub-region in the medium term to generate employment. The industry is however constrained by obsolescence of technology; lack of local expertise and poor production methods; poor industry

Corresponding Author: M. Affam, Geological Engineering Department, University of Mines and Technology, Tarkwa, Ghana

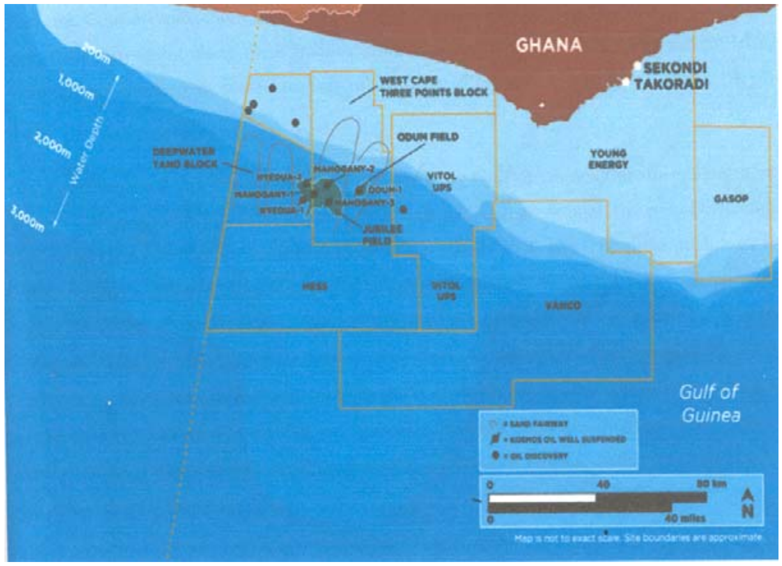

Fig. 1: Location of the Jubilee oilfield SW of Ghana (Anonymous, 2002).

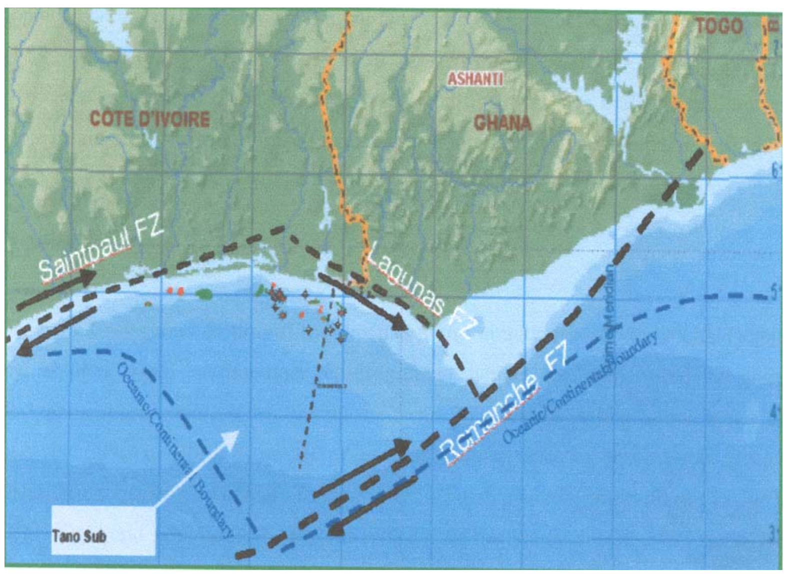

Fig. 2: Interconnecting boundary fault at the Jubilee Oil Field (Anonymous, 2002)

infrastructure; lack of economies of scale; low investment and lack of credit; cumbersome land acquisition procedures and land tenure administration systems.

Fortunately Ghana's recent oil find can enhance the prospect for the salt industry, since the market opportunity appears brighter. It is in this direction that this paper targets salt for accelerated development in Ghana.

MATERIALS AND METHODS

Ghana's oil find: The oil discovery in commercial quantities in Ghana has the potential of boosting the salt industry in the country. The oil field other known as the Jubilee oilfield is located west of Cape Three Point at the south western part of Ghana. It is bordered with Cote d'Ivoire in the west (Fig. 1) and the oil field lies within the Tano Sedimentary Basin sandwiched by interconnecting oceanic and continental boundary faults (Anonymous, 2002) (Fig. 2).

The field has immense potential for commercial quantities of oil and gas. Currently, 17 wells have been drilled with each well containing millions of barrels of oil and gas. Exploration drilling has indicated a proven reserve of about 300 million barrels of recoverable oil, making the discovery the largest offshore deep-water drilling in West Africa for over a decade. The oil field

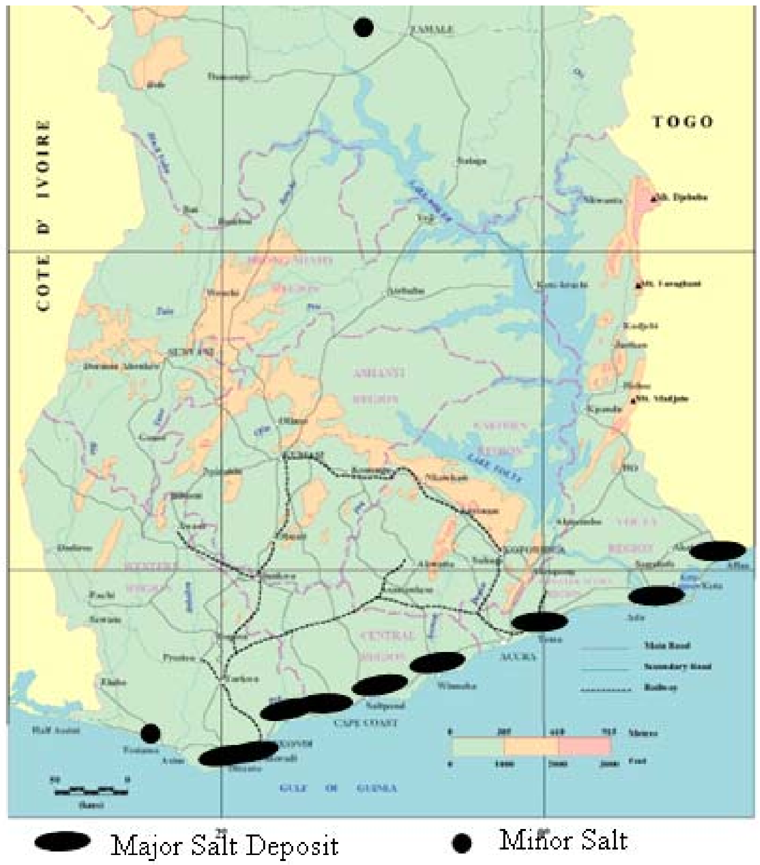

Fig. 3: Location of salt depositions in southern Ghana

will be developed in phases and it is projected to produce 120,000 barrels of crude per day.

The Jubilee field is jointly owned by Kosmos Energy, Tullows Oil, Anardarko Petroleum, Sabre Oil (of Ireland), GNPC and E.O. Group. These partners are expected to raise $5 billion to develop the field in phases. Production is expected to commence by the fourth quarter of 2010.

Salt production potential in Ghana: The potential of Ghana's salt industry could be brighten by the recent oil find. This is because the oil and allied industries uses large quantity of salt during for production. Both inland and oceanic sources of salt abound in Ghana, although emphasis so far has been more concentrated on the oceanic sources. The salt production areas in Ghana are mainly found in the coastal wetlands (Fig. 3), which are around the Keta Lagoon, the Songor Lagoon, the Densu Delta area, Nyanya lagoon, Oyibi lagoon, Amisa lagoon and Amwin/Benyah lagoon. The conditions for producing this type of salt get better from the west to the east along the coast, since there is a decrease in rainfall pattern.

The most coherent reason, according to the Ghana Meteorological Service Department is that east of longitude 2º W the coast line is oriented in such a way that, the prevailing moisture-laden winds (south-westerly trades) blow parallel to the shore line. Consequently, the full influence of the onshore winds is not felt inland resulting in less rainfall. However, west of longitude 2ºW, the same prevailing winds blow more perpendicularly across the coastline resulting in more rainfall in this region.

There are four different types of salt recovery namely: Rock Salt Mining, Solution Mining, Solar Salt and Processing of Rock Salt. Of these, the solar salt method is the most widely used in Ghana because of high evaporation rates and low precipitation that exist along the coast. In the solar salt method, sea water is made to enter or is pumped into ponds with dykes to prevent the water from escaping. It is continuously evaporated by solar heating and wind flow. As the water evaporates, its concentration rises and the constituent salt crystallises out. The crystallised salt is then washed to remove the insoluble matter like sand and as well as other impurities. It is then allowed to drain and dry in the sun.

Although some companies have made significant in-roll into the salt industry, their effort is marginal. These companies include Songor Salt Project Ltd., Ningo Salt

Ltd., Savannah Salt Company Ltd., Sege Salt Works Ltd., Dangbe Salt, Nyanyano Salt Association, Panbros Salt, Elmina and U-2 Co. Ltd. The rest are Adjua Salt Mining Company, Travevco Salt and Trading Ltd., Petua Salt and Company, John Haris, Modern Salt, Pakat Salt, Zam Salt Company Ltd., Trans Volta Salt and Sastin Salt Ltd. However, many of these companies are either defunct or currently non operational due to application of poor technology as well as other operational difficulties.

Salt demand in the ecowas sub-region: Salt production in the ECOWAS sub-region is located in Senegal, Ghana, Sierra Leone and Cape Verde Due to the wide uses of salt and the fact that its production is limited to few areas and subject to weather fluctuations, the demand for salt has always been very high. In the ECOWAS sub-region for instance, the demand for industrial salt is estimated at over 3 million metric tonnes per year for industrial use and over 1.5 million metric tonnes for human and animal consumption (Anonymous, 2004b).

The two countries (Ghana and Senegal) which have the natural facilities for producing salt on commercial basis, together, are able to produce barely 350 000 metric tonnes per year , leaving a very wide gap to be filled by imports from Brazil, Australia and Europe. Ghana can therefore develop her salt industry capabilities to satisfy a greater part of the salt demands of her neighbouring countries. The markets of Nigeria, Togo, Benin, Burkina Faso and La Cote D'Ivoire are natural export potential for the Ghanaian salt industry.

Climatic conditions for salt winning: It is estimated that the productivity of salt works in Ghana averages 1,600 ton/year/ha of crystallising area. Averagely, about 50,000 ha of land in the coastal regions of Ghana can be used for salt production. Land already licensed to be used for salt production is about 28,000 ha. It is observed that only about 40% of the licensed land is being used now for salt production, the rest lie idle (Quashie and Oppong, 2006). Analysis of climatic factors such as temperature, rainfall pattern, humidity, wind speed and the soil characteristics of the areas for salt production appear favourable

Rainfall: The movement of the Inter-Tropical Boundary (ITB) controls to a large extent the distribution of rainfall over the West African meteorological region. The ITB oscillates between the coast and latitude 20º N. As it moves north and south, it draws with it the associated weather zones. Thus, in January or February for instance, the region of localised thunder activity and disturbance are south of the Guinea Coast and the whole of Ghana lies in the cold dry North Easterly Trade Winds (Harmattan). Hence the climate of the coastal lands of Ghana, are among the driest in the country.

The rainy season has two maxima; the main (May/June) and the minor (September/October). June is the wettest month. According to the meteorological information, a narrow coastal belt, receives the lowest rainfall in Ghana during any given year. The total minimum annual rainfall recorded at the western coastal area of Ghana which happens to be the wettest area on the coast and also in the whole country is Axim. Minimum annual rainfall value of 1,169.2 mm and the high of 2,337.2 mm have been recorded. The eastern coastal area records the lowest rainfall.

Air temperature: The mean temperature along the coastal area has a simple seasonal rhythm, with a February-April crest and in July-August trough. The months with lower mean temperature are July to September, which correspond with the months of higher cloudiness of the year. The temperature regime varies from the minimum of 23-25ºC to a maximum of 31-34ºC.

Relative humidity: The relative humidity has the lowest values from December to February. During June to August, it records the highest of the year. The average relative humidity in percentage varies from 75% to 88%. The lowest relative humidity records correspond with the months of higher evaporative rates.

Wind: The prevailing wind direction is from the southwest all around the year (South-Westerly Trades) which is a characteristic feature of all the costal belt of the country. The wind speed is between 6.0-9.7 knots.

Evaporation: The angle of declination for solar radiation is very good in Ghana and this helps to increase the rate of evaporation on less cloudy days to acceptable levels. Those months with less evaporation values, correspond to those of higher cloudiness and thus, have a lower ratio between the total daily radiations onto a horizontal surface. The average daily net evaporation is estimated to be 4.8 mm in fresh water and 0.85 mm in saturated brine.

Land issues and the salt production constraints: Acquisition of land for some investment projects such as salt is a major obstacle to business development and economic growth in Ghana. Complex land tenure systems exist in the country where ownership is held by a combination of traditional authorities, families, private individuals and public or Government institutions. Public or state lands are compulsorily acquired by government through the invocation of appropriate legislation, vested in the president of the republic and held in trust by the state for the people of Ghana.

In contrast, private lands in most parts of the country are under communal ownership, held in trust for the community or group by a "stool or skin" as a symbol of traditional authority, or by a family. Between the public and private lands, are vested lands, which are held under a form of shared ownership between the state and the traditional owners. The land issues in coastal districts are not different from the national situation. Some of these lands which have great potential for salt production do suffer protracted litigation that makes it difficult for entrepreneurs to invest in the industry. However government interventions regarding land reform is addressing the issues.

A number of constraints continue to militate against the salt industry in Ghana. Although many of these are avoidable, they are persistent and slowing derailing the industry. The major set backs include:

- Improper procedure of land acquisition for salt production
- Salt producers are often a heterogeneous group consisting of co-operatives and individuals who operate outside legal or administrative framework
- Multiple small salt producers and erratic distribution patterns making management of .the programme difficult
- Poor production methods
- Obsolete equipment and low degree of mechanization

Salt mining methods: Generally there are four different types of salt recovery namely: *Rock Salt Mining*, *Solution Mining*, *Solar Salt* and processing of *Rock Salt* (Weller and Dumitroaia, 2005). Of these, the solar salt method is the most widely used in Ghana because of high evaporation rates and low precipitation that exist along the coast. Three methods of solar salt production have been identified in Ghana, namely: *Artisanal Salt* winning from lagoons during the dry season, *Traditional Solar Salt* production on small scale and *Modern Solar Salt* production on large scale. Apart from these, two others; the *Stoved salt* process and the *Brine Daboya Type* in the northern region are practiced in a very small rate

Traditional and modern solar salt production: These methods involve fractional crystallisation of various dissolved salts in lagoon or seawater in various ponds as the water is moved from evaporators through concentrators to crystallisers where sodium chloride is crystallised out (Fig. 4a-b).

In this modern solar salt method, sea water is pump to ponds with dykes to prevent the water from escaping (Fig. 5). It is continuously evaporated by solar heating and wind flow. As the water evaporates, its concentration rises and the constituent salt crystallises out. The crystallised salt is then washed to remove the insoluble matter like sand and as well as other impurities. It is then allowed to drain and dry in the sun. The range of salinity of the water in each of the ponds is regulated and is graded with the lower salinities in the evaporators and concentrators.

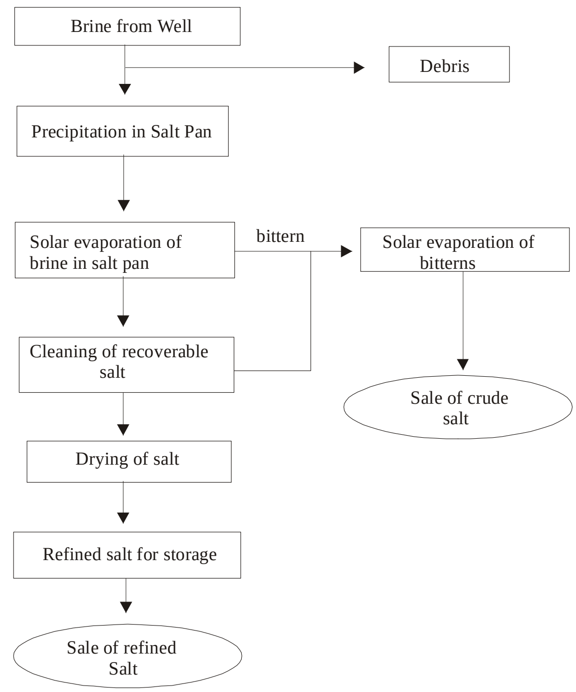

Fig. 4a: Flow chart of modern

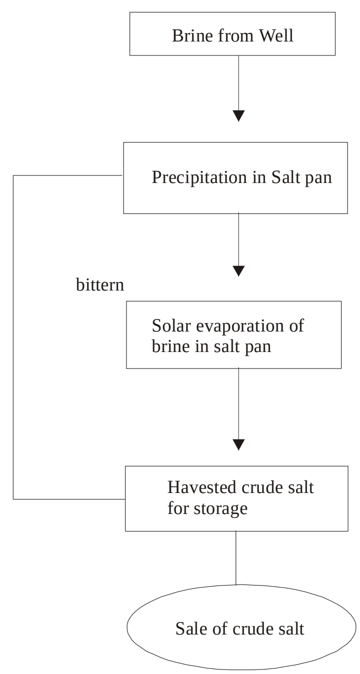

Fig. 4b: Flow chart of traditional salt production production

Characteristics of initial Brine: Coastal waters are under the influence of the Guinea Counter Current, which flows

Fig. 5: Solar salt production with dykes and ponds at Panbros (large scale production)

in a direction parallel to the coast. The prevailing winds are the south westerly trade winds which contribute to improve oceanic characteristics of the coastal water. This characteristic enhances a normal composition of the seawater, especially during the dry season which has average specific gravity of 1.024. The density of seawater (or initial brine) is 3.5º Baume' while sodium begin to precipitate out when brine density reaches 25.7º Baume' and specific gravity of 1.09.

Sampling procedure: In order to acquire 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 (Fig. 3). Due to seasonal variations in the quality of brine solutions, generally influenced by the seasonal change in rainfall, it was decided that each sample location be sampled twice in the year. The first sampling was therefore carried out immediately after the dry season (i.e., January) and the second one at the end of the rainy season (i.e., September).

At each location five kilogramme of salt was procured from at least 10 different producers. These were composted, quartered and about a kilogramme 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.

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

RESULTS

The s composite samples were analysed and the results of the sample from each locality is as presented in Table 1. The recommended threshold figures from Ghana Standard Board (GSB) are also presented for comparison.

Market analysis: Current salt production in Ghana is averagely between 250 000 and 300 000 tonnes per year (Fig. 6). This is about 10 % of the industry's potential that has been estimated at 2-3 million tonnes per annum. It is estimated that the current total installed capacity of solar evaporated salt production in Ghana is about 1.2 million tonnes per year but the industry doesn't reach the target. Actual production has consistently been below the installed capacity over the years due to rain water dilution, salt pan leakage, refining losses and salt transfer handling losses. Fig. 6 illustrates salt production trend from 1990-2007. In 2002, for instance, out of total world production of 210 million tonnes, Ghana's market share was 0.12%.

Ghana's export potential in the ECOWAS sub-region, the amount of salt being exported into the or traded between the 16 member countries is estimated to be 300 000 tonnes per year. The major importing nations are Nigeria, Cameroon, and La Cote D'Ivoire, Burkina Faso, Togo, Mali, Benin and Niger.

Typically, Ghana's salt export sequence especially between the years of 2000 and 2005 is nothing to write home about (Fig. 7). The year 2003 was among the worst

Table 1: Analysis of chemical constituents of common salt in mg/kg

	Salt type and location							
Elements	Panbros (large scale)	Songhor (large scale)	Keta (Traditional)	Songhor (Traditional)	Elimina (Artisanal)	Nyanyanu (Artisanal)	Axim (Stove)	GSB*
K	57300.00	54000.00	81000.00	115000.00	63000.00	72000.00	81000.00	Na
Na	915000.00	870000.00	993000.00	800000.00	960000.00	894000.00	690000.00	970000.00
Ca	228.94	159.34	219.13	208.34	67.78	147.14	208.34	2000.00
Mg	39.44	24.99	24.03	30.54	32.38	33.08	41.61	1000.00
Fe	5.88	10.96	18.56	1.86	6.00	8.16	7.16	10.00
Cu	6.56	6.34	6.84	2.80	6.72	6.88	7.16	2.00
Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2.00
As	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.50
Hg	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.10
Cd	2.00	2.28	2.44	0.80	2.00	1.64	1.32	0.50
SO_4	3415.38	2584.62	6599.99	29384.61	14861.54	3646.15	30276.92	5000.00
I	127.81	71.42	105.81	69.57	100.24	142.29	9.28	NA
Br	223.09	51.09	242.84	15.13	378.13	81.59	653.49	NA

* Ghana Standard Board

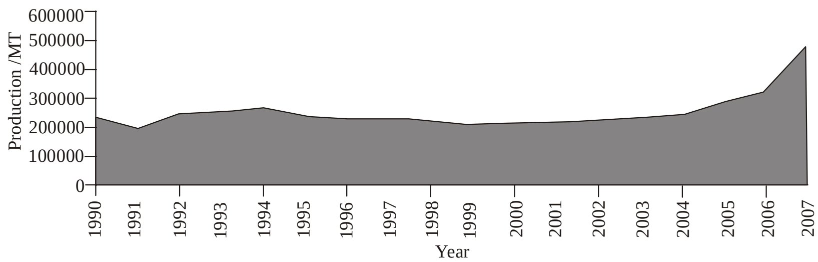

Fig. 6: Sequence of salt production in Ghana (Anonymous, 2004a)

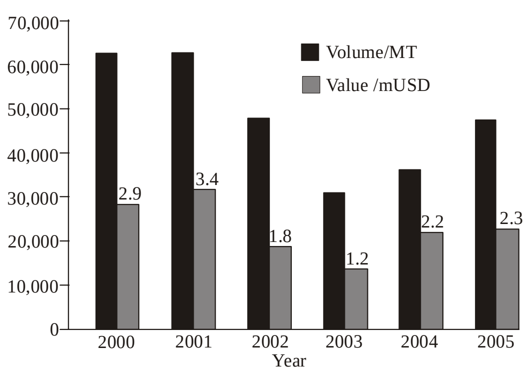

Fig. 7: Some appalling export performance sequence

performing years. Unfortunately things have not changed much till date. The market has been dwindling as other competitors improve.

To penetrate into an import market of 700,000-900,000 tonnes per year, Ghana needs to install modern low-cost, high production facilities capable to meet the available market. The initial phase of this entry would largely be achieved by displacement of marginal and inefficient production schedules and obsolete equipment.

Prospects for chloro-alkali industry: The ongoing construction for supply of natural gas from Nigeria to Ghana and the recent discovery of of-shore oil deposit at Cape Three Points in Ghana give brighter prospects for an integrated chemical complex plant. Ghana's natural gas deposits could also further enhance the development of the chemical industry. High demand for basic chemicals in the ECOWAS justifies for the establishment of a chloro-alkali and related chemical industries in Ghana based on availability of salt.

It is observed that the chemical industry alone can consume about 95% of salt production with only about 5% for human consumption. Market potential for chloro-alkaline demand in Ghana indicates that, the soap industries are the major importers of caustic soda to the country. For the period 1992-1996, about 36,395 tonnes of caustic soda costing $17 million was imported by the processing industries. Imports of hydrochloric acid in Ghana have also increased significantly since early 90's. In 1981 the import of hydrochloric acid was only 109 tonnes but this jumped to 2,194.74 tonnes in 1996 costing over one million dollars and the figures have not come down. The gold mining boom and gold refineries are increasing the demand and are creating more opportunities for the chloro-alkaline production in country.

DISCUSSION

Analysis of elemental quaility of solar salt produced from both small and large scale production units generally do no deviate so much from GSB recommended threhold values. It is seen that Sodium (Na) except the traditional salt from Keta falls fairly within the recommended level of 970000 mg/kg.

It is observed that the sulphate content of three samples namely, Panbros and Songhor and an artisanal (Elmina) types are all within the permissible limit of 5,000 mg/kg with the Songhor factory recording the lowest level of 2584.62 mg/kg. Two samples from Keta and Axim however produced salts with high sulphate contents of 29,384.61 and 30,276.92 mg/kg, respectively which needed to be addressed. On the average Cd and Cu levels recorded is higher than the 0.5 mg/kg and 2.0 mg/kg recommended by GSB.

The country's strategic position, favourable climatic conditions, large coastal land size stretching over 500 km and conducive environment encourages the promotion of the salt industry Despite constraints, the availability of the markets potential within the country, created by the oil discovery in commercial quantities as well as the open market in the sub-region, gives enough impetus to the promotion of the salt industry. It is observed that the chemical industry alone can consume about 95% of salt production. Considering this high demand for chemical and allied industries, Ghana's abundant solar energy could be sourced to aid salt production and establish a regional plant for the chloro-alkali industry (i.e., chlorine, caustic soda (sodium hydroxide) and soda ash (sodium carbonate)).

CONCLUSION

The study concludes that:

- Ghana possesses one of the largest proven renewable solar salt production potential along the coast of West Africa. The entire coastline stretching over a distance of over 500 km can be useful for salt production.
- Test analysis indicates that currently the salts do not appear to meet the standard specifications set by Ghana Standard Board (GSB). The salt generally is low in Na, K, Ca and Mg. The mean value of NaCl in the salt is 87.59 % which is much lower than the required level of 97%.
- Elemental analysis of impurities in the solar salt is high. Cadmium and copper levels recorded are higher than 0.5 and 2.0 mg/kg, respectively recommended by GSB.
- It is envisaged the salt industry can be transformed into competitive one with enhanced modern facilities for the production of good quality salt for domestic and export markets, Production can be increased from the current 250,000 metric tonnes per year to margins around 2 million metric tonnes per year.
- The industry is however constrained by: obsolescence of technology; lack of local expertise and poor production methods; poor industry infrastructure; lack of economies of scale; low investment and lack of credit; cumbersome land acquisition procedures and land tenure administration systems.
- It is also expected that value addition through a viable chloro-alkali industry could be developed to partner the salt industry to generate higher income

RECOMMENDATION

The following recommendations are being made to fully utilise the salt industry to contribute to the economic growth of this country:

- Salt harvesting must be mechanised to increase production.
- In order to improve salt production, these major production zones should be strategised for commercial take-off: Keta; Ketu; Dangbe East; Dangbe West; Weija; Gomoa-Awutu-Effutu; Mfansiman and Ahanta areas.
- Land can be made accessible by involving land owners as equity share holders to check land litigation.
- Salt refinery must be established to add value to the product for greater financial returns.
- Strategic alliance must also be established with major world producing countries

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