PURIFICATION AND EVALUATION OF SALT FROM AKIRI BRINE SPRING

BY

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A RESEARCH PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF CHEMICAL ENGINEERING, SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE BACHELOR'S DEGREE OF TECHNOLOGY IN CHEMICAL ENGINEERING.

OCTOBER, 2003

CERTIFICATION

This is to certify that the project titled "purification and evaluation of salt from Akiri brine spring" was carried out by YAKUBU STEPHEN under the supervision of Eng. M.A. OLUTOYE and submitted to the department of chemical Engineering, School of Engineering and Engineering Technology of the Federal University of Technology Minna in partial fulfillment of the requirement for the award of a Bachelor of Engineering (B. ENG.) Degree in Chemical Engineering

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DEDICATION

This report is dedicated to my creator because without Him I am nothing. He is the reason for my living and existence for I am complete in Him. Also to my parent, brothers and sisters for making me a part and then impacting me with the wisdom of Almighty God, creating a conducive environment for me, which brought forth the potentials in me.

ACKNOWLEDGMENT

I thank God, my father who has been faithful to me, not only during the course of this project but throughout my stay in the University. Without His love and mercy, none of this would have been possible.

I also say thank you to my supervisor Eng. M.A. Olutoye. He gave advice and encouraged me at all time, believed in me even when I had doubts.

My profound gratitude goes to my parents: my father, Mr. Yakubu Alibeku and My mother, Mrs. T. Y. Alibeku, my brothers and sisters: Daniel, Vincent, Micah, Victoria, Helen and Hussaina I say a big thank you! To me for their love and support, which I don't deserve it. I also thank you for nurturing given me the basis foundation of knowledge in all aspect of life.

Special thanks to my mentor Pastor Mike O. Paul who had been rendering support and encouragement all the way. I cannot help but mention the following people. Without them this project would not have been possible. They are: Mr.Yakubu Isah, Engr. M. A. Olutoye, Zakari Nuhu, Vincent Alibeku and Jibriel Mohammed. Who gave the necessary information and push to completion of this work.

ABSTRACT

The research work on the purification of Akiri brine spring salt (ABSS) has been carried out. Samples of brine were collected from the spring and subjected to various purification processes. First, the decolourization using activated charcoal; secondly the heating of solution at about 91^{0}C to produce white crystals of salt.

The process characterization was done by analysing the sodium and potassium content of akiri salt, laboratory produced salt and common salt using flame photometer. The physical properties i.e viscosity, colour, specific gravity and solubility were determined and the values of these physical quantities were 1.25x $10^{-3}NSm^{-2}$, white, 2.162, and 8.5 mole/ dm^3 for purified Akiri brine spring salt.

Thus when compared to the standard obtained for common salt, it was found that the purification processes was adequate and is recommended for use.

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CHAPTER ONE

1.0 INTRODUCTION

Salt is a chemical compound formed when one or more of the hydrogen atoms of an acid are replaced by one or more cations of the base or group of atoms, which is electropositive such as an Ammonium ion, $NH4^+$ is known as a Salt (McGRAW-HILL, 1982).

Spring is a place where ground water discharges upon the land surface due to natural flow form a deep seated, hot or cold, pure of mineralized water. The spring water differs in composition from meteoric water through exchange of element between water and rocks. Mineral spring water as high concentration of solute, salts are source for solute in some instances, chlorine-rich water in marine sedimentary rock also contain bromine iodine and boron. During metamorphism of the rock the water may be retained as fluid inclusion or films along grain boundaries. The retained brines in the metamorphic form the saline springs.

1.1 USES/ADVANTAGES

PRESERVATIVE: The uses in the food preservative industries includes:

- In meatpacking, salt is added to fresh meat as a preservative.
- Animal skins and hides are pickled with slat before being processed into leather.
- Brine is used extensively in refrigerator and cooling processes.

AGRICULTURE: The uses in the Agricultural sectors includes:

- Salt provide the ideal carrier for supplying minerals and trace element in the diet of animals.

INDUSTRIES: The uses in the industry includes:

- In ceramics, for surface verification of heated clay.
- In textiles dying, for standardizing the strength of individual batch of dye and for setting the dye unto the Tiber.
- In soap making, for separation of soap from water.
- Leather tanning, prevention of bacterial decomposition in hides.

PETROLEUM: The uses in the petroleum industry, includes for inhibiting formation of starch in well-drilling mud and for preventing dissolution of rock salt strata during drilling operation.

1.2 AIMS/OBJECTIVES: The objectives of the work include the following:

i. To estimate the potassium (K) and sodium (Na) salt produced from the sample collected from Akiri brine.

ii. To advance the local manufacturing process (HEATING) using more developed method to obtain a purified sodium (Na) salt for the growing of the economy of the nation.

iii. To test if other component of trace element is in the salt produced.

1.3 SCOPE

In this process of manufacturing salt from Akiri brine, concentrated brine is decolorized using activated charcoal, filtered and evaporated. The mortar is used to crush lumps into white crystals and screen. This method affort more opportunities for purification of the salt. The flame photometric is used to compare the present of trace element in the laboratory-produced salt. Additive is used to prevent the formation of hard mass.

1.4 LIMITATIONS:

The hindrance encounter using flame photometric technique to analyse in salt making includes:

i. Instrumental errors due to fluctuations and a lot of minor adjustment to achieve stability during the experiment.

ii. The flame photometer operation is time consuming,

- Put 'ON' for about 30 minutes to warm up
- Distill water used to put the reading instrument to zero level.

iii. Salt is liable to clumbing during the period of high humidity.

iv. The salt crystal surface wetted, screening process for the pebbles becomes difficult.

v. The difficulty in transporting to the site due to poor road network in the state.

CHAPTER TWO

2.1.0 LITERATURE SURVEY

2.1.1 HISTORY

Common salt (sodium chloride) is a mineral substance of great importance to the health of man and animals It is got naturally from deposits of salt water, seas water or beneath the rock. Sodium chloride is a fine-grained salt that is universally used for domestic and industrial purposes. It is a hygroscopic substance.

Iodized salt is a salt in which small quantities of potassium iodide (KI) is added and used where iodine is lacking from the diet, a situation which results into swelling of the thyroid gland and is called Goiter.

Below is the composition of Dead Sea water (Kirk Othmer, 1969).

COMPOSITION OF SEA WATER

ITEM	WEIGHT (%) SURFACE WATER
Sodium Chloride	2.68
Sodium Bromide	0.008
Magnesium Chloride	0.32
Magnesium Sulfate	0.22
Calcium Sulfate	0.12
Potassium Chloride	0.07
Calcium Chloride	1.154
Water	95.428
TOTAL	**100.00**

OCCURRENCE

ORDINARY SALT: It is cheap and available in the market. It is non toxic and is used in food preparation.

SEAWATER: Though the material which give sea water its salty taste comprises of many substances including sodium chloride (which is by far the most predominant compound), the rock salt (magnesium sulfate or calcium sulfate) which is 2.24 times as dense as water, it has been estimated that if the oceans of the world completely dried up, they would yield about 4,500,000 cubic miles of rock salt (McGraw Hill Encyclopedia).

ROCK SALT: This is also referred to as true sedimentary rocks, which has been the mineralogical name of HALIDE. It occurs widely in the form of rock masses. All major rock salt deposit originated from the evaporation of seawater and 78% of the mineral matter in normal seawater is sodium chloride (McGraw Hill Encyclopedia 1979).

Upon evaporation of about nine-tenth of the volume of seawater, rock salt is precipitated. Deposits are found in the bed from a few feet to may hundreds of feet thick many extremely thick rock salt bed were deposited in partly enclosed arm of the sea in which evaporation is greater than the flow of salt water. Another important type of rock salt deposit is the salt domes formed when the earth pressure force up plug of rock salt measuring approximately a mile across. Many domes occur at shallow depth and are extensively mined. An interesting feature of some rock salt deposits is the occurrence of pure, crystallized salt, found in quantities from very small isolated patches to several tons. This salt is extremely clear and free form defects; it is about 99.98% pure sodium chloride (Kirk Othmer 1969).

AKIRI SALT: The brine is water containing high concentration of salt; brine salt is obtained in underground water, which comes form rock as origin.

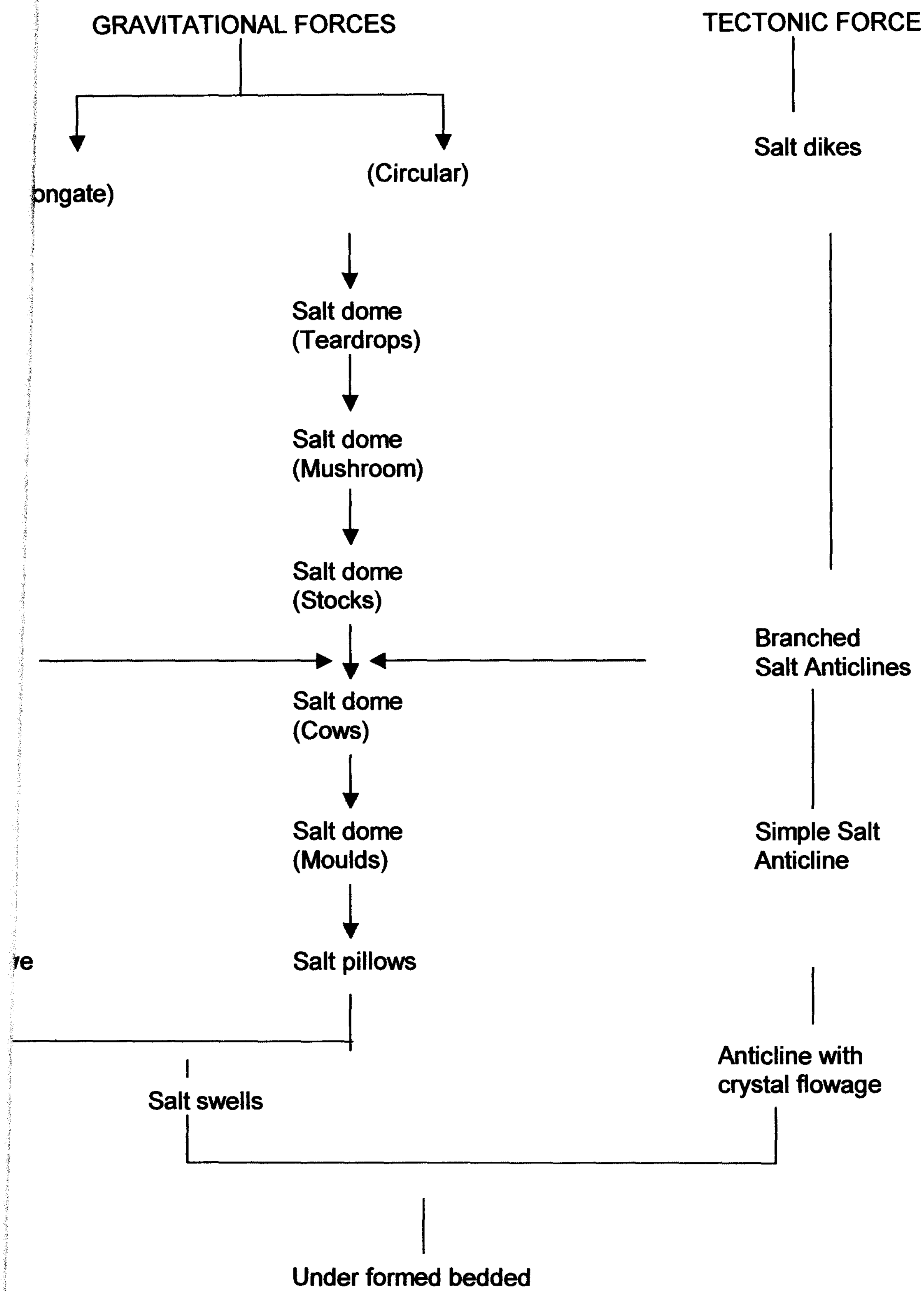
The brine flow naturally from the underground water to the land surface and the salt deposits are source of solute (NaCl) and contain other minerals.

At the spring site a channel of out flow of brine solution is constructed and brine solution continue to accumulate in an open land. The brine percolate down the soil while the water content of the brine evaporate due to heat form the sun, the dry sand is called SALT SAND. The salt sand is characterised by dry surface, cracks, and salty taste.

The salt sand is scrape and drop in a clay pot for collection of concentrated salt solution. A brownish salt is made by evaporating of the brine solution at a temperature 85^0C, Akiri salt contains a very high percentage of impurities.

SALT DOMES: These are structurally developed as a result of gravitational force and tectonic force. The tectonic forms appear as a result of pressure that pushes the salt up through the rock from a depth.

The interrelationship between Gravitation force and tectonic force is as shown diagrammatically below.


GRAVITATIONAL FORCES
TECTONIC FORCE
ongate)
(Circular)
Salt dikes
Salt dome
(Teardrops)
Salt dome
(Mushroom)
Salt dome
(Stocks)
Branched
Salt Anticlines
Salt dome
(Cows)
Salt dome
(Moulds)
Simple Salt
Anticline
ve
Salt pillows
Anticline with
crystal flowage
Salt swells
Under formed bedded

2.1.2 PROPERTIES OF COMMON SALT

i. At room temperature it is a colourless, transparent cubic crystal. It is a hygroscopic salt because it absorbs atmospheric moisture to form solid lumps.

ii. Common salt is only one of a large number of electrolytic compound classified as salt (Sodium Chloride), in mineralogy is known as Halide. The compound occurs as a mineral in the form of crystal or granules (McGraw Hill Encyclopedia).

iii. The density is 2.165 heavier than H_2O at O^0C (32^0F), it melts without decomposing and become a vapour at 1440^0C ($2624\ ^0F$). The salt is soluble in alcohol and also in glycerin, slightly soluble in liquid ammonia and insoluble in concentrated hydrochloric acid. These properties are used in the recovery and crystallization of common salt (McGraw Hill Encyclopedia 1979).

iv. Under the influence of an electric current, molten salt decompose to form metallic sodium ion and chloride ion. Its aqueous solution form caustic soda and chlorine.

v. The crystals have a tendency to take up water from atmosphere, so it must be kept in a room at a controlled humidity.

2.1.3 PRODUCTION

The commercial production of salt by evaporation of seawater, salt water and rock salt include the following: Solar evaporation, vacuum evaporation, grainer salt, open pan evaporation and Alberger process.

2.1.3 (I) SOLAR EVAPORATION

The salt is produced from seawater and it is one of the simplest processes used when the heat form sun evaporates the brine solution in an open pond. The concentrated brine is run through a series of small crystallizing pans where salt of varying grades is deposited. The best grade salt is obtained in the first crystallizing pan (small size particle). Countries that practice this method include: Nigeria, France and U.S.A.

II. VACUUM EVAPORATION

The vacuum evaporation consist of series of three or more closed vessels, it has a steam chamber totally submerged in the brine solution to be evaporated. The steam chamber has a vertical tube, well arranged with surface area for transferring the heat of steam to the brine (Kirk Othmer, 1969).

The first vessel receives steam from an outside source (often exhaust steam from the turbines of electric generators) and the brine in the first vessel begins to boil. The vapor given off into water and drained off. The boiling brine however, is now generating its own steam, which is piped over to the second vessel of the series and transfers its heat to the brine. In the same way to the third vessel and so on.

The steam released from the brine in the last vessel of the series is condensed by cold water. The condensation of the steam from the boiling brine in each vessel produces a reduction in pressure, and because of this the brine boils at temperature lower than it would be the case at ordinary atmospheric pressure.

The salt crystals taken from the bottom of the vessels and pumped into the filter, which separates the salt crystals, form the brine. The salt is then taken by belt conveyor, which passes through a drier to produce dried salt, which is stored in silos.

III. GRAINER SALT

This type of salt is made by evaporation of brine in a long swallow pan. The daily capacity of such grainer salt may be 80 tonnes. A scraping conveyor continuously removes the crystallizing salt from the bottom of the grainer. The salt is then filtered, dewatered, dried, cooled and rolled to break the lumps.

IV. ALBERGER PROCESS

The salt brine is heated to a high pressure and then passed to a gravellier. A gravellier is a large cylindrical vessel filled with stone, which serves as a deposition site for calcium sulphate. The brine and salt mixture is discharged to a large open pan; the crystallized salt is pumped to a centrifuge for dewatering, than tried in a rotary dryer (Ralph Hancock, 1978).

2.1.4 DECOLOURIZATION OF CONCENTRATED BROWNISH BRINE

Activated charcoal is a highly porous solid material, which is widely used as an absorbent and a catalyst carrier.

The uses of activated charcoal includes:

a. Water treatment for odour, taste and colour removal.

b. For decolourization in salt and sugar industry.

c. Gas purification

2.1.5 ADDITIVES

Salt is liable to clumping during the period of high humidity, so preventives are added. The materials used include magnesium carbonate and certain silicates. Iodides are added where iodine deficiency exist (Kirk Othmer, 1969).

CHAPTER THREE

3.1 INSTRUMENTATION

In this experiment, the following material/equipment were used.

a. Triple stand and clamp

b. Beaker

c. Funnel

d. 1000 cm^3 round bottom flask

e. Glass rod

f. Fitter paper

g. Activated charcoal

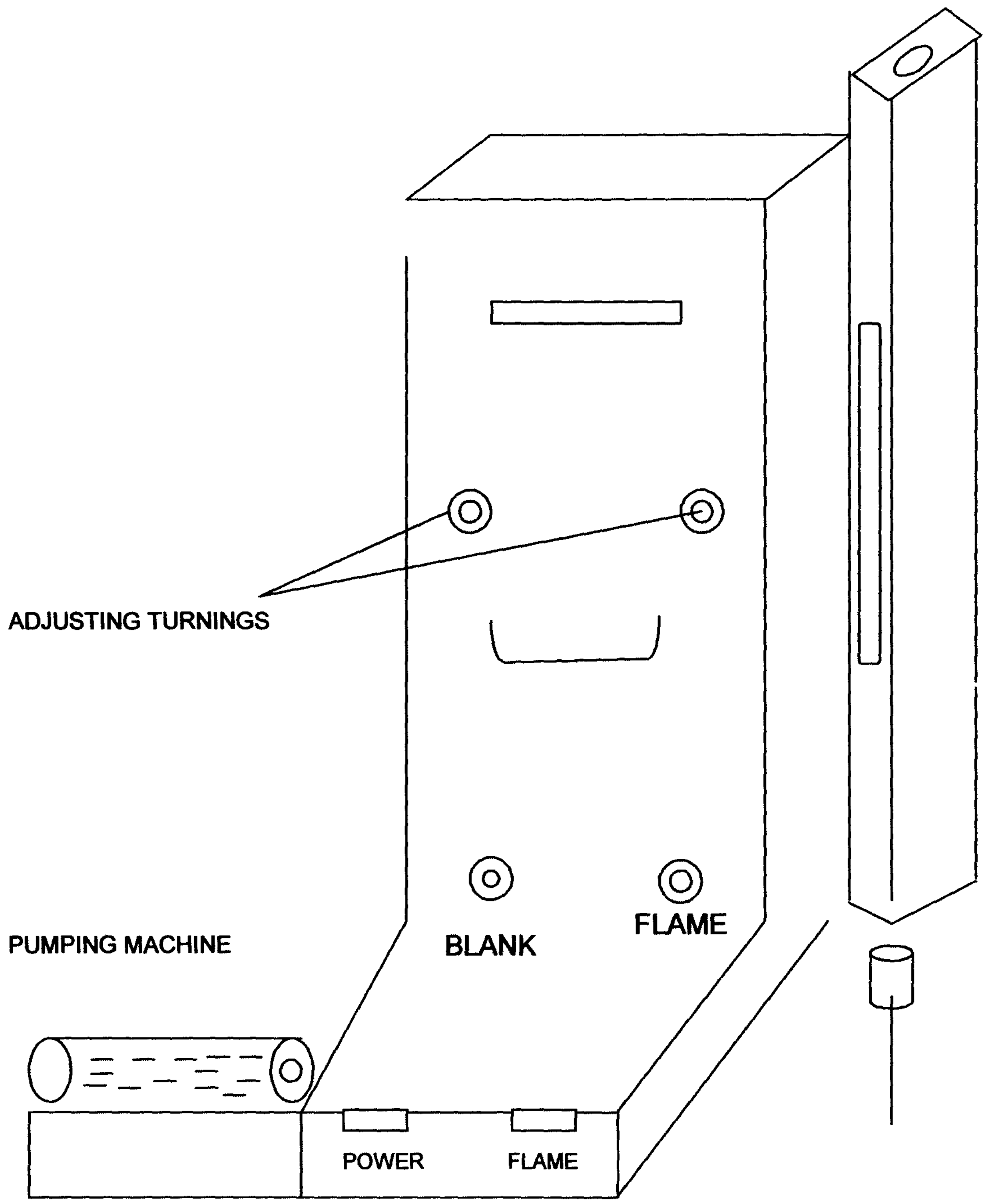
h. Conical flask

i. Crucible

j. Thermometer

k. Weighing balance

l. Flame photometer


ADJUSTING TURNINGS
PUMPING MACHINE
BLANK
FLAME
POWER
FLAME

SCHEMATIC: DIAGRAM OF FLAME PHOTOMETER

3.2 METHODOLOGY

3.2.1 PURIFICATION PROCESS

i. A sample of about 95g (0.095kg) of salted sand from Akiri brine spring site was introduced into a swamp water rubber; cut at the bottom with an opened mouth held by a triple stand and clamp upside down. A brine directly form the spring was introduced into the swamp water rubber at the top that contained the concentrated salted sand. This was allowed to stand over night, the next day a fresh sample of concentrated brine was collected in a conical flask beneath the swamp water rubber.

ii. 5g (0.005kg) of activated charcoal was introduced into the concentrated brine solution in a Beaker and mixed with a glass rod for one minute, filtered using a fitter paper on top of the funnel. A conical flask was used beneath to collect a colourless solution of the brine.

iii. After decolourisation, the brine was heated in a crucible, which boils at temperature 91^0C . Maintaining constant temperature (91^0C), the brine boiled continuously for about one hour fifteen minutes and formed salt of uniform crystals (moist). The salt crystals were spread during the day (HOT SUN) to achieve a complete dry white salt.

3.3 PREPARATION OF STANDARD SOLUTION

This is done in order to determine the purity of the various samples of the brine solution.

I. **AKIRI SALT SOLUTION:** A solution was made form concentrated Akiri salt, using distill water and filtered (Filter paper) to obtain a light brown solution labeled sample A.

II. **PURIFIED AKIRI BRINE SOLUTION:** To prepare a sample using brine solution, activated charcoal and fitter paper as explained 3.2 (ii). A colourless brine solution was obtained at the end of the process labeled sample B.

III. **FILTERED AKIRI BRINE SOLUTION:** This process is explained 3.2 (i) and a brown concentrated brine solution was obtained. The brine was filtered using a filter paper labeled sample C.

3.4 QUALITATIVE ANALYSIS

This is concerned with the determination of the constituent of the sample without regard of the actual amount of the substance

3.4.1 DETERMINATION OF SODIUM AND POTASSIUM ION FROM THE SAMPLE

i. How to prepare 1000 ppm of sodium (Na) using sodium chloride (NaCl)

NaCl ——— ——— ——— ——→ 58.5g (molecular weight)

$\therefore$ 58.5g of NaCl contain 23g of Na

1.00g of Na is contain $\frac{58.5g}{23}$ = 2.54g

2.54g of NaCl was accurately measured and dissolved in a distil water and made up to one liter mark 1.00g of sodium per ml which is 1000 ppm and was labeled as STOCK SOLUTION. From the stock solution a serial dilution was made and calculated using V. Alexeyer Formula and obtained result as follows.

a. 10 ppm 2 ml in 100 ml

b. 8 ppm 1.6 ml in 100 ml

c. 6 ppm 1.2 ml in 100 ml

d. 4 ppm 0.8 ml in 100 ml

e. 2 ppm 0.4 ml in 100 ml

The stock solution 2 ml, 1.6 ml, 1.2 ml, 0.8 ml and 0.4 ml were accurately measured using a pipette and pipetting into 100 ml conical flask and diluted to 100 ml, each give the standard 10 ppm, 8 ppm, 6 ppm, 4 ppm and 2 ppm respectively with a distilled water.

ii. To prepare 1000 ppm of potassium using potassium chloride (KCl).

KCl ———— ———— ———— ——→ 74.5g (molecular weight)

39_g potassium is contain in 74.5g KCl

$$\frac{74.5}{39} = 1.9 \text{ KCl}$$

1.00g of potassium is contained in

Therefore, 1.9g KCl was accurately measured and dissolved in distilled water made up to one liter to give 1000 ppm, which was used as stock solution, this contains 1.00 mg of potassium per ml. The stock solution from V. Alexeyer Formula calculation of 2 ml, 1.6 ml, 1.2 ml, 0.8 ml, 0.4 ml were accurately measured and pipetting into a 100 ml conical flask and diluted to give a standard of 10 ppm, 8 ppm, 6 ppm, 4 ppm and 2 ppm taken from the original stock solution.

3.4.2 DETERMINATION OF PHYSICAL PROPERTIES

I SOLUBILITY:

100CM^3 of distilled water was measured and poured into a 250 CM^3 beaker, and small amount of sodium Chloride 35.7g, 36.0g, 36.3g, 36.6g, 37.0g, 37.3g, 37.8g, 38.4g and 39.0g was accurately measured.

With constant stirring, little by little the weight sample (NaCl) added to 100 CM^3 water inside a beaker. The solution was heated at a temperature 0^{0}C, 10^{0}C, 20^{0}C, 30^{0}C, 40^{0}C, 50^{0}C, 60^{0}C, 70^{0}C, 80^{0}C, and 90^{0}C respectively. The amount of Sodium Chloride that dissolve in the water at a given temperature is called solubility.

II. COLOUR

Crystalline salt sample (NaCl) was obtained and prepared for accurate measurement of colour I light-coloured. Monochromatic light has a special lamp containing sodium Vapour that is used to measure light brown to off White colour white colour. The same colour is obtained from the frame of a Bunsen burner if grains of common salt (NaCl) are used.

III. VISCOSITY

A viscometer was filled with liquid to a level of just below the exit from capillary tube. The distance between upper point X and lower point Y was 0.73m and the diameter screw gauge range between 1.5X 10^{-4} to 2.0X10^{-4}m.

The ball was released from an open end of the tube and fell freely through the liquid bottom. The time taken from X to Y was 10 sec. This process was repeated with two other balls of different diameter. The density of the liquid 964.60kg/m^3 was measured by pychnometer and the temperature 27^{0}C was measured by a thermometer. In a falling sphere viscometer, a spherical ball is allowed to fall freely under the influence of gravity and he thermal velocity is measured. Stokes equation is then used to evaluate the viscosity.

Thus, $\mu = \frac{r^2(\rho_s - \rho_L)g}{u}$

Where r = radius of ball

g = gravitational acceleration = 9.8m/s^2

ρ_s = density of ball

ρ_L = density of fluid

u = average terminal velocity.

μ = Viscosity

IV. SPECIFIC GRAVITY.

The term specific gravity denotes the ratio of the density of a substance to the density of a reference substance.

To determine the specific gravity of Akiri brine, micrometer screw gauge was used to find the dimension of test sample A (Akiri brine) the sample weighed 21.62g while the volume is 10cm^3

Density of brine = $\frac{\text{Mass}}{\text{volume}}$

= $\frac{21.62(g)}{10\ (CM^3)}$ = 2.1629/cm^3

Hydrometer jar filled with a sufficient quantity of water and the scale marking corresponding to the depth of immersion. The density of water is determined to be approximately $1 g/cm^3$.

Thus the specific gravity of Akiri brine = $\frac{\text{Density of brine}}{\text{Density of water}}$

= 2.162

3.5 QUANTITATIVE ANALYSIS

This deal with the determination of the actual amount of substance, which is usually expressed in unit such as gram.

3.5.1 ESTIMATION OF THE QUANTITY OF SALT PRODUCED FROM THE RAW CONCENTRATE.

Fresh sample prepared from Akiri brine solution 10ml, 20ml, 30ml, 40ml, and 50ml were accurately measured using a measuring cylinder and their corresponding weight 10.9/g, 21.07g, 31.87g, 42.62g and 52.75g respectively. The samples were heated maintaining a constant temperature of (80-91^{0}C) and the weight after evaporation was recorded as 5.87g, 10.17g, 16.10g, 21.57g and 26.69g respectively.

3.6 DETERMINATION OF THE QUALITY OF THE IMPROVED SALT.

A fresh sample of Akiri brine was poured into a beaker, 4g of activated carbon was introduced into the sample and mixed thoroughly with a glass rod for one minute.

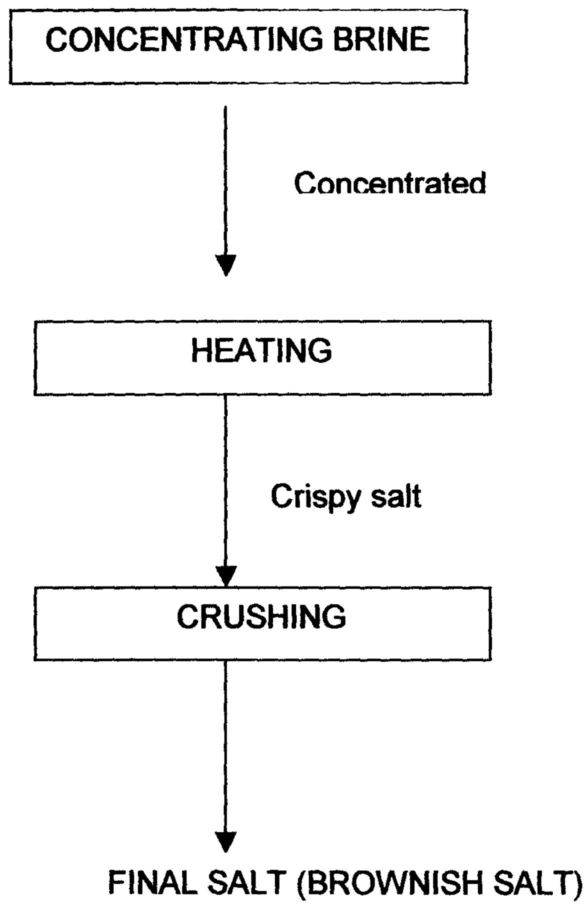
A filter paper was folded and fitted closely into the funnel. The mixture was poured into the funnel and beneath it a conical flask was used to collect the colourless solution. The solution mixture passed through because the particles dissolved are too small to be retained by the filter paper. The solid matter retained is called filtrate. The addition of activated charcoal is to transform the brown solution into colourless solution.

3.7 READINGS FROM FLAME PHOTOMETER

Flame photometer is an instrument used to detect the present of trace element (Na, K, Li). The flame photometer was put "ON" for about 30 minutes to warm and the gas line was also put "ON" the instrument was set up to zero using a distilled water, various concentration of samples were sued up to the highest and reading were noted. At each reading distilled water was used to zero the instrument.

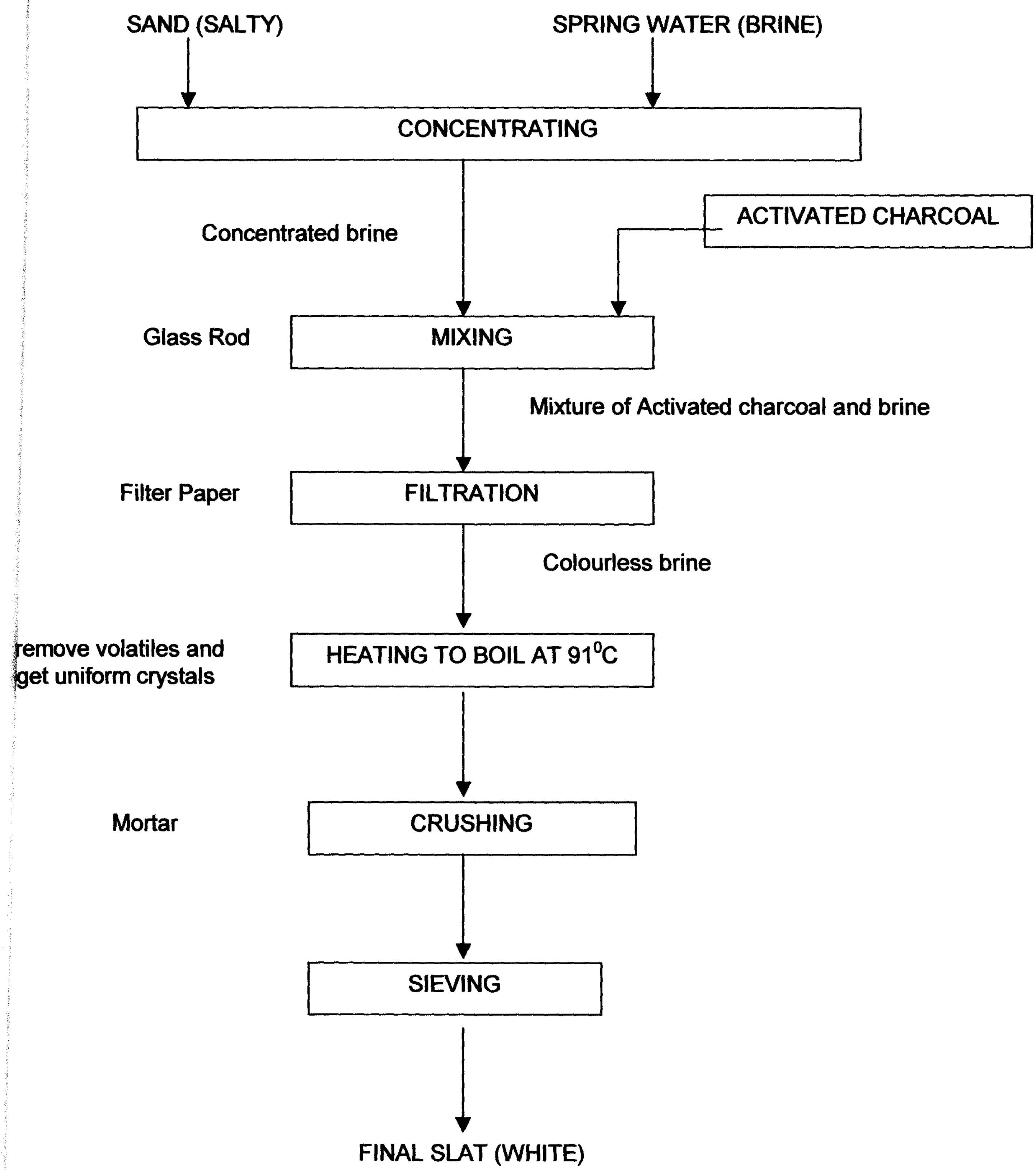
After calibration of the instrument the concentration of standard solution corresponding to the samples were recorded.

3.8 PROCESS FOR LOCAL PRODUCTION OF SALT



Local production of salt from Akiri Brine spring

3.9 IMPROVED METHOD OF SALT PRODUCTION



Improved method of producing salt form Akiri brine spring

CHAPTER FOUR

4.1 RESULTS AND DISCUSSIONS

4.1.1 TABLE SHOWING READINGS FOR DETERMINATION OF POTASSIUM ION

K^+ STANDARD SOLUTION	% EMISSION
0.00 ppm	0.00
10.00 ppm	34.00
20.00 ppm	60.00
30.00 ppm	82.00
40.00 ppm	100.00
DICON SALT	03.50
THREE STARS	03.00
UNCLE PALM	04.00
AKIRI SALT	30.50
FILTERED AKIRI BRINE	22.50 x dF 10
PURIFIED AKIRI BRINE	21.50 x dF 10

dF=correction factor

SAMPLES	K^+ CONCENTRATION (mg)
DICON SALT	012.50
THREE STARS	011.20
UNCLE PALM	014.00
AKIRI SALT	117.50
FILTERED AKIRI BRINE	087.50
PURIFIED AKIRI BRINE	082.50

4.1.2 TABLE SHOWING READINGS FOR DETERMINATION OF SODIUM ION

Na^+ STANDARD SOLUTION	% EMISSION
0.00 ppm	0.00
20.00 ppm	38.00
40.00 ppm	62.00
60.00 ppm	82.00
80.00 ppm	89.00
100.00 ppm	100.00
DICON SALT	57.20
THREE STARS	57.40
UNCLE PALM	54.20
AKIRI SALT	57.00
FILTERED AKIRI BRINE	66.30
PURIFIED AKIRI BRINE	65.40

SAMPLES	Na^+ CONCENTRATION (mg)
DICON SALT	422.00
THREE STARS	423.70
UNCLE PALM	402.00
AKIRI SALT	420.50
FILTERED AKIRI BRINE	487.50
PURIFIED AKIRI BRINE	480.00

4.1.3 YIELD DETERMINATION

Volume of Akiri Brine (ml)	Weight before Heating (g)	Weight after Heating (g)	Weight after Heating of Purified salt	Amount of water Evaporated (g)
10	10.91	5.87	5.27	5.04
20	21.07	10.17	9.15	10.90
30	31.87	16.10	14.30	15.77
40	42.62	21.57	19.17	21.05
50	52.75	26.69	23.69	26.06

4.1.3 SOLUBILITY TABLE.

S/NO.	TEMPERATURE (^0C)	MASS IN GRAM OF SATURATED SOLUTION
1	0	35.70
2	10	35.80
3	20	36.00
4	30	36.30
5	40	36.60
6	50	37.00
7	60	37.30
8	70	37.80
9	80	38.40

4.2.0 DISCUSSION OF RESULTS

The samples from site, salt sand, concentrate brine and Akiri salt was analysed using flame photometric analysis to determine potassium, sodium and the complete decolourization of the brown salt to white salt. From the result obtained and compared with the accepted value sold in the market, it was found that there was significant achievement in the decolourization of Akiri salt and the laboratory produced slat in the course of investigation.

The salt sample form Akiri was found to be more heavier (weighing) but on treatment with activated carbon, the weigh decreased and could be as a result of impurities that were present in the salt sample. Standard solutions were prepared of 0.00ppm, 20.00ppm, 40.00ppm, 60.00ppm, 80.00ppm and 100.00ppm respectively and it corresponding percentage emission recorded with the aid of photometer for both potassium and sodium determination. A graph was plotted, percentage emission of the samples against concentration of standard solution. The emission of Akiri salt, filtered salt, purified slat and common salt were trace on the graph to obtain their corresponding concentrations.

Finding the different brand of common salt Dicon salt, three stars and uncle palm marked A, B, and C with 12.50mg, 11.20mg and 14.50mg respectively for potassium in each examples.

Laboratory produced salt marked A^L, B^L and C^L with 117.50mg, 87.50mg and 82.50mg respectively for potassium content. The sodium content was found to be 422.00mg, 423.70mg and 402.00mg respectively for common salt samples marked A, B, and C. The laboratory-produced slat marked A^L, B^L and C^L was found to be 420.00mg, 487.50mg and 480.00mg respectively.

The physical analysis of Akiri Salt enable us to calculate these parameters: viscosity is $0.00125Nsm^{-2}$, specific gravity is 2.162, and solubility at room temperature (2.7^0C) is 37.5g of saturated solution and these parameters conformed with the standard value written in Chemical Engineering Handbook for 20lit raw concentrate of Akin salt, the amount recoverable is 9150g and the amount of water evaporated is 10900g. The estimate of 15 drums/day, the annual production is 512.5 tons/year (20,500 bags of salt). The physical and chemical analysis of Akiri salt proves that it is good for human consumption.

The comparison is shown in the table below.

POTASSIUM (mg):

COMMON SLAT	PRODUCED SALT	AKIRI SALT
12.50	82.50	117.50

SODIUM (mg):

COMMON SLAT	PRODUCED SALT	AKIRI SALT
422.00	480.00	420.00

Despite the experimental error in the course of this investigation, there is achievement recorded apart from minor adjustments to achieve stability during this experiment.

CHAPTER FIVE

5.1.1 CONCLUSION

Within the limits of experimental errors, the samples collected from Akiri brine spring was analysed using flame photometric analysis. The brown salt was decolourized using activated charcoal.

From the result obtained and compared with the accepted value sold in the market shows that it is good for human consumption and a raw material for Nigeria industries.

RECOMMENDATION

* To design a plant with large quantity and quality of slat, it is suggested that arrangement should be made for its development and probably pilot plant study and the setting up of the plant in the villages having brine springs in Nasarawa State, hence a steady supply of raw material.
* Flame photometer is limited to analyse three elements (Li, Na and K). Other elements need to be analysed in the slat sample includes: Mg, Mn and Cl. Modern equipment should be made available to determine these elements.
* The transport network in Awe Local Government of Nasarawa State is very poor. It is therefore recommended in this study, the road transport and waterway transport should be reconstructed for further investigation.

APPENDIX

1. MANIPULATION OF DATA

A. POTASSIUM DETERMINATION

Standard solution for potassium determination 0.00ppm, 10.00ppm, 20.00ppm, 30.00ppm and 40.00ppm

Determination of percentage emission with the aid of flame photometer

NO	STANDARD SOLUTION	PERCENTAGE EMISSION
1.	0.00ppm	0.00
2.	10.00ppm	34.00
3.	20.00ppm	60.00
4.	30.00ppm	82.00
5.	40.00ppm	100.00

NO	SAMPLES	PERCENTAGE EMISSION
1.	Akiri salt	30.50
2.	Filtered salt	22.5 x dF 10
3.	Purified salt	21.5 x dF 10
4.	Dicon salt	03.50
5.	Three star salt	03.00
6.	Uncle palm salt	04.00

From the graph plotted % emission against concentration of standard solution. The above samples were trace on the graph to get it corresponding concentration

NO	SAMPLES	K^+ CONCENTRATION (PPm)
1.	Dicon	12.50
2.	Three star	11.20
3.	Uncle palm	14.50
4.	Akiri salt	117.50
5.	Filtered Akiri brine	87.50
6.	Purified Akiri brine	82.50

SODIUM DETERMINATION

Standard solution for sodium determination 0.00ppm, 20.00ppm, 40.00ppm, 60.00ppm, 80.00ppm and 100.00ppm

Determination of percentage emission with the aid of flame photometer

NO	STANDARD SOLUTION	PERCENTAGE EMISSION
1.	0.00ppm	0.00
2.	20.00ppm	38.00
3.	40.00ppm	62.00
4.	60.00ppm	82.00
5.	80.00ppm	89.00
6.	100.00ppm	100.00

NO	SAMPLES	PERCENTAGE EMISSION
1.	Dicon	57.20
2.	Three star	57.40
3.	Uncle palm	54.20
4.	Akiri salt	57.00
5.	Filtered Akiri brine	66.30
6.	Purified Akiri brine	55.40

From the graph plotted % emission against concentration of standard solution. The above samples were trace on the graph to get it corresponding concentration.

NO	SAMPLES	Na^+ CONCENTRATION (PPM)
1.	Dicon	422.0
2.	Three star	423.7
3.	Uncle palm	402.00
4.	Akiri salt	420.00
5.	Filtered Akiri brine	487.50
6.	Purified Akiri brine	480.00

CONVERSION OF ppm TO mg

A. POTASSIUM DETERMINATION

0.1g salt sample weight and dissolve in 100ml

i. Off-curve reading of Dicon salt = 1.250ppm k^+ (1250mg/ml)

1ml of sample contain 1.250ppm K^+

100ml of sample will contain 125ppm K^+

This was contain in 0.1g sample

100 gram of sample will contain $125 \times \frac{100}{0.1}$ ppm K^+

$$= 125 \times \frac{100}{0.1} \times 10^{-6} \text{mg } K^+$$

$$\%K^+ = 125 \times \frac{100}{10} = 12.50\text{mg}$$

ii. Off-curve reading of three star = 1.120ppm K^+ (1.20mg/ will contain ml)

100g of sample $112 \times \frac{100}{0.1}$ ppm K^+

$$= 112 \times \frac{100}{0.1} \times 10^{-6} \text{mg } K^+$$

$$\%K^+ = \frac{1.12}{10} \times 100 = 11.20\text{mg}$$

iii. Off-curve reading of uncle palm = 1.450ppm K^+ (1.450mg/ml)

100g of sample will contain $145 \times \frac{100}{0.1}$ ppm K^+

$$= 145 \times \frac{100}{0.1} \times 10^{-6} mg\ K^+$$

$$\%K^+ = \frac{1.45}{10} \times 100 = 14.50mg$$

iv. Off curve reading of Akiri salt = 11.75ppm K^+ (11.75mg/ml)

100g of sample will contain $11.75 \times \frac{100}{0.1}$ ppm K^+

$$= 11.75 \times \frac{100}{0.1} \times 1175^{-6} mg\ K^+$$

$$\%K^+ = \frac{11.75}{10} \times 100 = 11.75mg$$

v. Off curve reading of Filtered salt = 8.75ppm K^+ (8.75mg/ml)

100g of sample will contain $8.75 \times \frac{100}{0.1}$ ppm K^+

$$= 8.75 \times \frac{100}{0.1} \times 10^{-6} mg\ K^+$$

$$\%K^+ = \frac{8.75}{10} \times 100 = 87.50mg$$

vi. Off curve reading of Purified Akiri salt = 8.25ppm K^+ (8.25mg/ml)

100g of sample will contain $8.25 \times \frac{100}{0.1}$ ppm K^+

$$\%K^+ = \frac{8.25}{10} \times 100 = 82.50mg$$

B. SODIUM DETERMINATION

0.1g salt sample weight and dissolved in 100ml

i. Off-curve reading of Dicon sample = 42.20ppm Na^+ (42.20mg/ml)

1ml of sample contain 42.20ppm Na^+

100ml of sample will contain 4220ppm Na^+

ii. Off-curve reading of three star = 42.37ppm Na^+ (42.37mg/ml)

100g of sample will contain $4237 \times \frac{100}{0.1}$ ppm Na^+

$$4237 \times \frac{100}{0.1} \times 10^{-6} Na^+$$

$$\%Na^+ = \frac{42.37}{10} \times 100 = 423.70 \text{ mg}$$

iii. Off curve reading of uncle palm = 40.20ppm Na^+ (40.20mg/ml)

100 m of sample will contain $40.20 \times \frac{100}{0.1}$ ppm Na^+

$$4020 \times \frac{100}{0.1} \times 10^{-6} Na^+$$

$$\%Na^+ = \frac{40.20}{10} \times 100 = 402.00 \text{ mg}$$

iv. Off curve reading of Akiri salt = 42.00ppm Na^+ (42.00mg/ml)

100g of sample will contain $40.00 \times \frac{100}{0.1}$ ppm Na^+

$$4200 \times \frac{100}{0.1} \times 10^{-6} Na^+$$

$$\%Na^+ = \frac{42.00}{10} \times 100 = 402.00 \text{ mg}$$

v. Off curve reading of filtered Akiri salt = 48.75ppm Na^+ (48.75mg/ml)

100g of sample will contain $48.75 \times \frac{100}{0.1}$ ppm Na^+

$$4875 \times \frac{100}{0.1} \times 10^{-6} Na^+$$

$$\%Na^+ = \frac{48.75}{10} \times 100 = 480.50 \text{ mg}$$

vi. Off curve reading of purified Akiri salt = 48.00ppm Na^+ (48.00mg/ml)

100of sample will contain $48.00 \times \frac{100}{0.1}$ ppm Na^+

$$4800 \times \frac{100}{0.1} \times 10^{-6} Na^+$$

$$\%Na^+ = \frac{48.00}{10} \times 00 = 480.00 \text{ mg}$$

TO DETERMINE THE QUANTITY OF SALT PRODUCED FOR A 20 LITER RAW CONCENTRATE

For 20ml: The quantity of salt produced after heating 10.17g, 20000ml = 20 lit.

I. AMOUNT AVAILABLE FOR 20 LITRE RAW CONCENTRATE

If 20ml produced 10.17g of salt

20 liter of raw concentrate will produce

$$\frac{20{,}000 \times 10.17}{20} = 10170\text{g of salt.}$$

ii AMOUNT RECOVERABLE AFTER PURIFICATION

If 20ml produced 9.15g of purified salt

20 liters raw concentrate will produce

$$\frac{20{,}000 \times 9.15}{20} = 9150\text{g of purified salt .}$$

iii AMOUNT OF WATER EVAPORATED AFTER HEATING

20ml evaporates 10.90g of water

20 liter will evaporate

$$\frac{20{,}000 \times 10.90}{20} = 10900\text{g of water .}$$

PERCENTAGE OF SALT PRODUCED FOR 20 LITER CONCENTRATE

Weight of salt after heating =10170g

Total weight of concentrate =21070g

$$\% \text{ salt} = \frac{10170}{21070} \times 100$$

=48.30%

$$\% \text{ impurity of salt} = \frac{10170 - 9150}{21070} \times 100$$

= 4.84%

$$\% \text{ of water evaporated} = \frac{10900}{21070} \times 100$$

= 51.73%

ESTIMATION OF QUANTITY PRODUCE FOR 15 DRUMS

Akiri village salt produce 15 drums/ day of raw concentrate

1 Drum = 180 liter.

15 Drums = 2,700,000 ml of raw concentrate

If 20ml produced 10.17g of salt

Then 15 Drums will produce

$$\frac{2,700,000 \times 10.17}{20}$$

= 1372950g of Akiri salt.

= 1372.950kg of Akiri salt

Number of bags per day

$$\frac{1372.950kg}{25kg}$$

55

Number of bags per year = 55 x 31 x12

= 20,460.

This implies Akiri village is capable of producing 20500 bags of salt annually.

PHYSICAL PROPERTIES CALCULATIONS

I Solubility of NaCl in water at room temperature 27°C

Mass of the saturated solution = 38.00g

Mass of the solvent evaporated = 30.00g

Mass of the dry residue NaCl = 10.17g

Molar mass of NaCl = 40.00g

Mass of dissolved NaCl =10.17g

Molarity of dissolved NaCl = $\frac{10.17}{40}$ =0.254 moles

1g of water =1cm^3 of water

30.00g of water is saturated by 0.254 mole of NaCl

1000cm^3 of water will be saturated by

$\frac{1000 \times 0.254}{30}$ mole of NaCl

= 8.5 moles of NaCl

Solubility of NaCl in water at room temperature (27^{o}C) is

8.5 moles/dm^3

ii Viscosity: Stokes equation is used to evaluate viscosity

$r = 1.5 \times 10^{-4}$ m

g =9.8m/s^2

ρ_s = 10250kg/m^3

ρ_L =964.647kg/m^3

u = 0.05034

$\mu = \frac{r2(\rho s - \rho l)g}{u}$

$= \frac{(1.5 \times 10^{-4})^2 (1250 - 964.647) \times 9.8}{0.05034}$

= 0.00125

= 1.25×10^{-3} Nsm^{-2}

iii Specific gravity

Density of brine = $\frac{21.62g}{10cm^3}$ = 2.162g/cm^3

But density of water is approximately $1 g/cm^3$

$$\text{Specific gravity} = \frac{\text{Density of brine}}{\text{Density of water}}$$

$$= \frac{2.162}{1}$$

$$= 2.162$$

3. SOURCE OF ERROR

i. Un-calibrated instruments do not read accurately

ii. Fluctuation of electricity supply

iii. Fluctuation and minor adjustment of the flame photometer

iv. The neutralisation of instrument to zero level for each sample

v. Humid environment result the formation of hard mass when the sample is expose

4. PRECAUTION

i. Instrument should be calibrated be used

ii. Steady supply of electricity

iii. The samples should be kept in a control environment

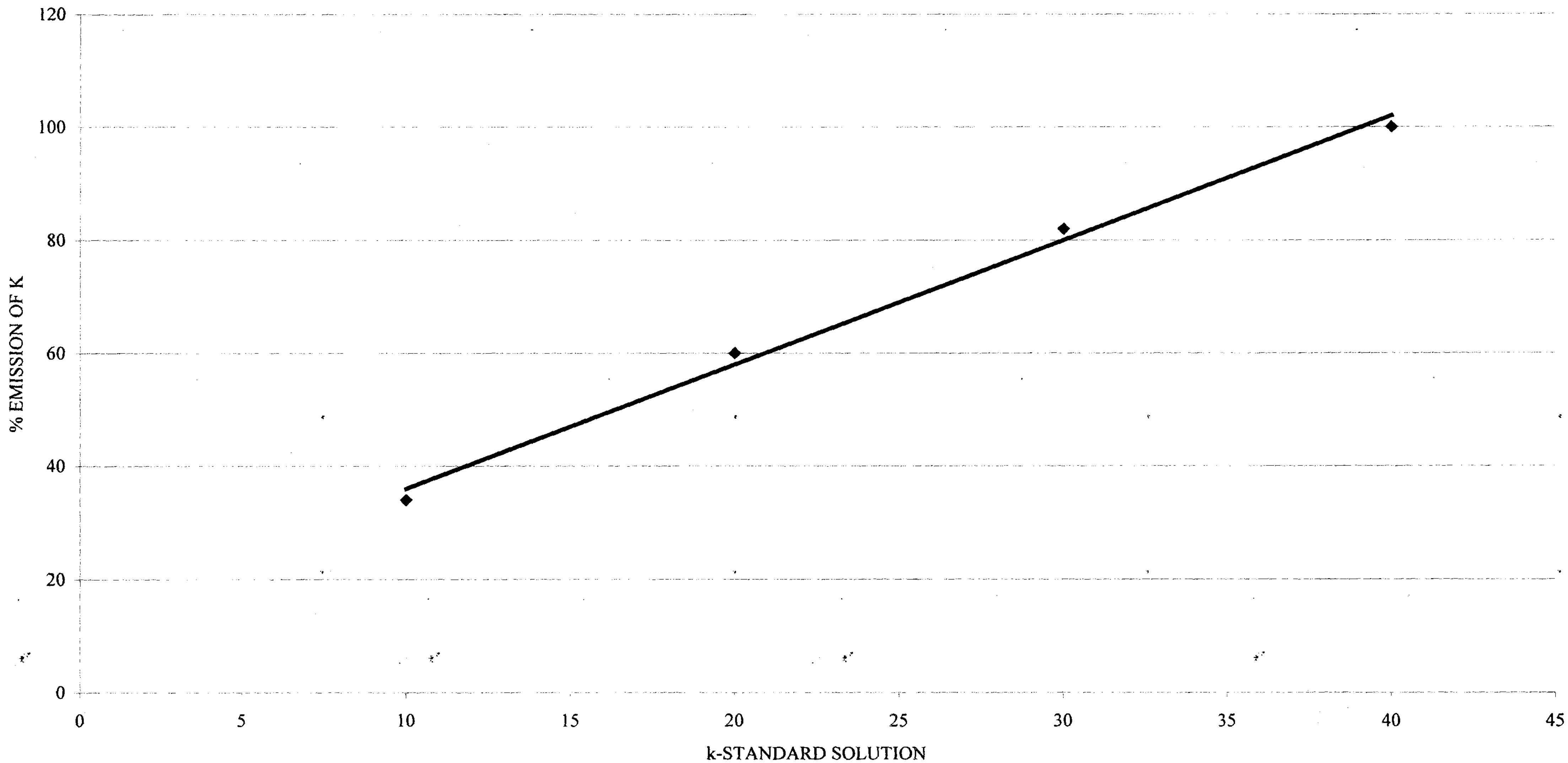
iv. Improve instrument should be brought

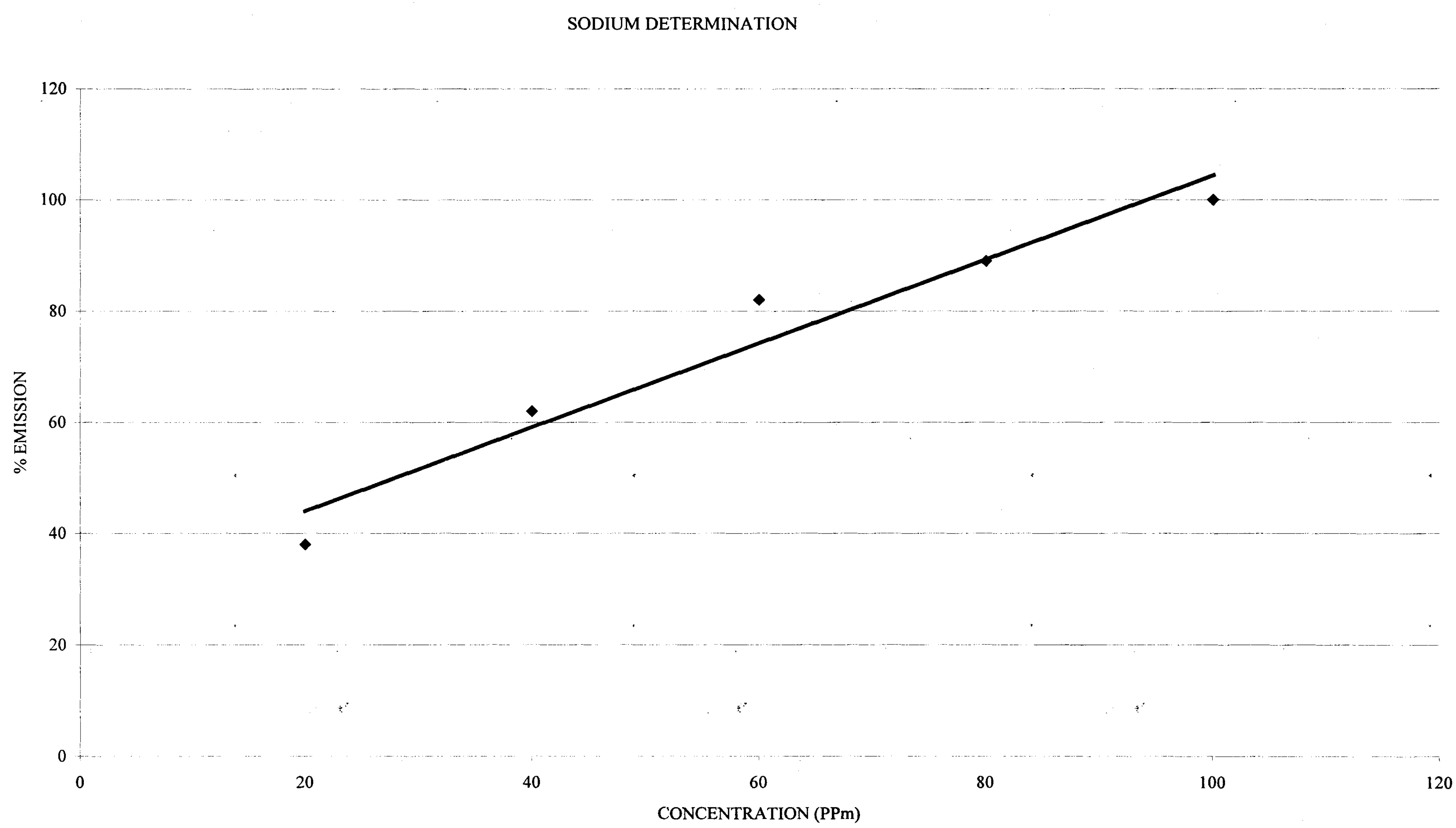
NOMENCLATURE

Symbol	Definition	Dimention
ρs	Density of ball	M/L^3
ρl	Density of fluid	M/L^3
g	Gravitational acceleration	L/T^2
r	Radius of ball	L
U	Average terminal velocity	L/T
μ	Viscosity	ML/T^2
%	Percentage	

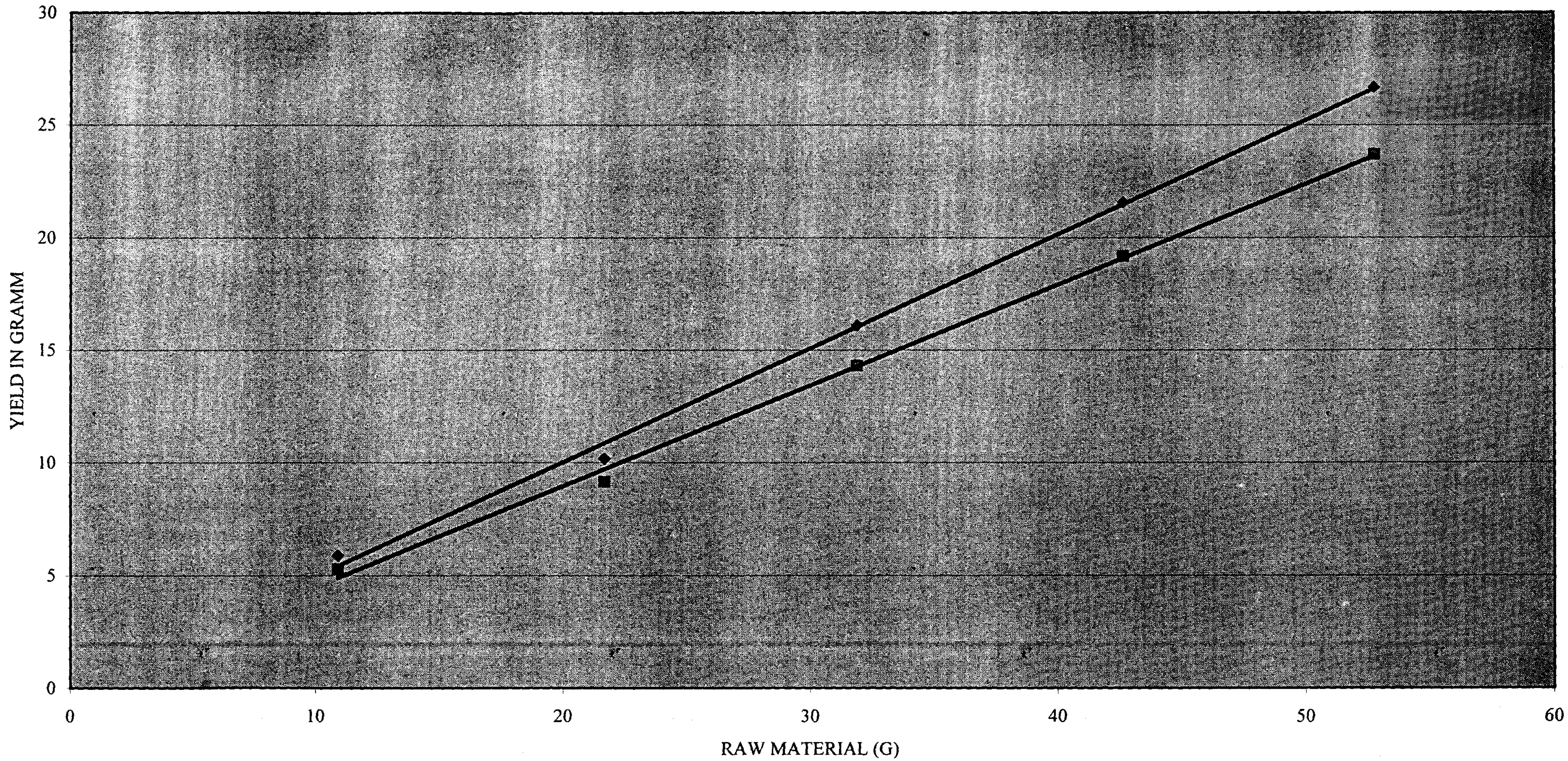
Ppm	Part per million	
Mg	Milligramm	
Sp.gr	Specific gravity	
ρ	Density	M/L^3

POTASSIUM DETERMINATION GRAPH

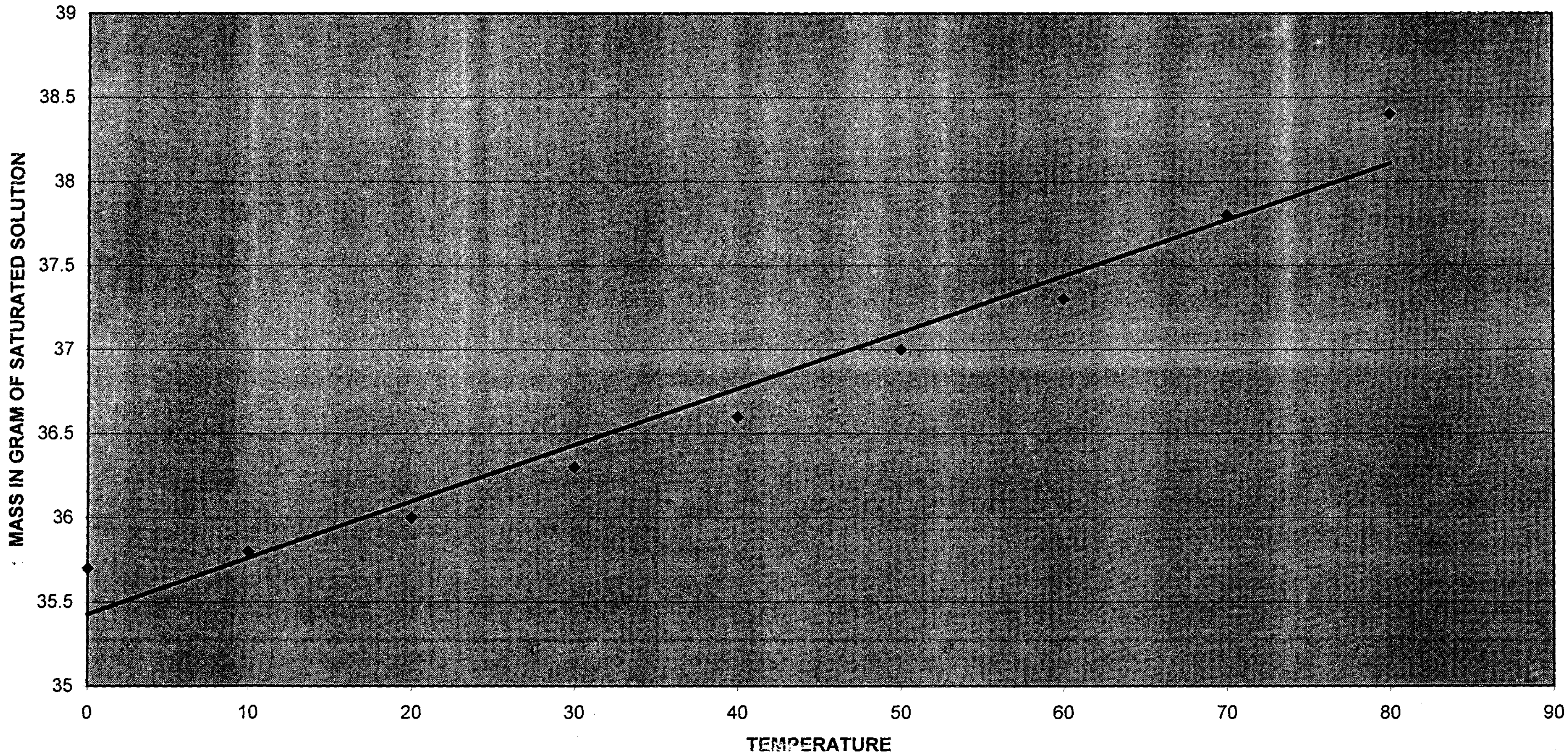



SODIUM DETERMINATION
% EMISSION
120
100
80
60
40
20
0
0
20
40
60
80
100
120
CONCENTRATION (PPm)

YIELD DETERMINATION GRAPH



SOLUBILITY CURVE FOR NaCl



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