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The Use of Statistical Quality Control Tools to Access the Quality of Water Produced. A Case Study of Dalung Headworks, Ghana Water Company Limited –N/R

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Abstract

Considerable Water can be said to be one of the most important social amenities in the world. Humans, animals and plants alike depend on water for a lot of uses. For such a valuable commodity, it would be necessary to ensure that its production meets quality standards, so as to prevent the spread of water-borne diseases. Addition of various chemicals to remove impurities must also be controlled. There are choices of methods through which quality in many manufacturing processes could be checked. The leading objective of this project was to determine the quality of treated water supplied to urban areas from the Ghana Water Company Limited. The case study was the Dalung Headwork in the northern region, which supplies water to Tamale metropolis and its environs. Methods used to analyze the data were statistical quality control tools by the aid of SPSS, specifically, control charts.Using Range and Mean control charts, it was discovered that all stages of the water production process were statistically out of control, and there were large variations due to avoidable or assignable causes.

Keywords: Accessing water quality, statistical quality control methods, Ghana-northern region

1.INTRODUCTION

Water is essentially the basis for all life. All living things invariably depend on water for their survival. Water is a very unique substance. In fact, it is the only natural substance that is found in all three physical states, that is, liquid, gas and solid, at the temperatures normally found on Earth. As solid, it can be found as snow, hail or ice caps on water surfaces. As liquid, it can be found as rain droplets or dew on vegetation. Also, it covers three-quarters of the Earth’s surface as rivers, oceans, lakes and swamps. It occurs also in its gaseous form (water vapour) as steam or fog.

Water is a major component of plant and animal matter. Blood in animals and sap in plants consist largely of water and serve to transport food and remove waste material. Fifty to ninety percent of the weight of living organisms is water.

It is the prime duty of governments worldwide to provide good, safe and quality water for its citizens. Water, like any other product, must meet quality standards. Major world bodies like the World Health Organization (WHO) help, especially, developing countries to improve the quality of water they produce. Drinking water of poor quality has serious consequences. WHO estimates that two million deaths annually are attributed to unsafe water, sanitation and hygiene alone. WHO further estimates that more than 1 billion people do not have access to clean water worldwide. It is also reported that more than 50 countries still report cases of cholera to WHO. Also, the United Nations estimates that 6 to 8million people die annually from the consequences of disasters and water-related diseases. The lack of clean drinking water and sanitation systems is a severe public health concern in Ghana, contributing to 70% of diseases in the country. Consequently, households without access to clean

The lack of clean drinking water and sanitation systems is a severe public health concern in Ghana, contributing to 70% of diseases in the country. Consequently, households without access to clean water are forced to use less reliable and hygienic sources, and often pay more.

Water quality be a measure of how suitable water is for a use. This makes water quality subjective. For instance, water used for watering flowers may meet its standards, but it might not necessarily be good for humans to drink.

Ghana Water Company Limited, herein referred to as GWCL, is a state owned limited liability company established on 1st July 1999, following the conversion of Ghana Water and Sewerage Corporation (GWSC) under the Statutory Corporations Act 461 of 1993.

The first public water supply system in Ghana was established in Accra just before World War 1. Later, other water supply systems were established in other urban areas like Cape Coast, Winneba and Kumasi, and were all managed by the Hydraulic Division of the Public Works Department. Consequently, the Department of Rural Water Development was established in 1948 to develop and manage rural water supply through the drilling of boreholes and construction of wells for rural communities.

In 1957, a Water Supply Division was established under the Ministry of Works and Housing with responsibilities for both rural and urban water supplies. Its headquarters was in Kumasi.

A major national crisis that propelled the development of water supply in Ghana was the dry season of 1959, which caused severe water shortage nationwide. Following this, an agreement was signed between the Government of Ghana and the World Health Organization for a study to be conducted into water sector development in the country.

The study led by WHO recommended the establishment of a national water and sewerage authority, thus the formation of the Ghana Water and Sewerage Corporation. The primary responsibilities of the Ghana Water and Sewerage Corporation were:

i. Water supply and sanitation in rural as well as urban areas.
ii. The conduct of research on water and sewerage as well as the making of engineering surveys and plans.
iii. The construction and operation of water and sewerage works.
iv. The setting of standards and prices and collection of revenues.

By the late 1970s and early 1980s, the operational efficiency of GWSC had declined to very low levels mainly because of deteriorating pipe connections and pumping systems. A World Bank report in 1998 states that: “The water supply systems in Ghana deteriorated rapidly during the economic crises of the 1970´s and early 1980´s when Government’s ability to adequately operate and maintain essential services was severely constrained.”

Various sector reforms and improvement projects were undertaken in 1970, 1981 and 1988 to improve the water supply system in Ghana. These reforms did make some gains, but generally had no impact on service delivery. However, in 1987, a “Five-Year Rehabilitation and Development Plan” for the sector was prepared which resulted in the launching of the Water Sector Restructuring Project (WSRP). This was a major boost for water supply in Ghana. In line with this, many reforms were initiated in the early 1990s:

i. Responsibilities for sanitation and small-town water supply were decentralized and moved from Ghana Water and Sewerage Corporation to the District Assemblies in 1993.
ii. The Environmental Protection Agency (EPA) was established in 1994 to ensure that water operations would not cause any harm to the environment.
iii. The Water Resources Commission (WRC) was founded in 1996 to be in charge of overall regulation and management of water resources utilization.
iv. In 1997, the Public Utilities Regulatory Commission (PURC) came into being with the purpose of setting tariffs and quality standards for the operation of public utilities.
v. Community Water and Sanitation Agency (CWSA) was established in 1998 to be responsible for management of rural water supply systems, hygiene education and provision of sanitary facilities.

Then, finally, the Ghana Water and Sewerage Corporation was converted to the now Ghana Water Company Limited, with the responsibility for urban water supply only.

The Ghana Water Company Limited, besides producing water for urban communities in Ghana, is responsible for ensuring that the produced water is safe for public consumption. WHO has set standards for which factors that make wholesome water must meet. These factors include the pH level, color, chlorine content, turbidity, temperature and many others. The study seeks to use statistical quality control measures to check if these parameters are in control.

i. To assess the quality of treated water at the Dalung Head works in the northern region using quality control tools.
ii. To detect sources of variation in the water production process.
iii. This study will educate and inform consumers on the quality of water supplied to them. It will also assist quality control officers at the Ghana Water Company Limited (DALUNG-HEAD WORKS) in their daily quality checks.

limitations of the study

i. Researchers had minimum time to finish their work. They had to simultaneously get information for their study, while considering other academic work.
ii. Some production managers were reluctant to release information on production due to confidentiality issues.
iii. Relative difficulty in getting books on the research topic.

2.METHOD STUDY DESIEGN AND SAMPLE

The study is an analytical of a secondary data of Dalung headworks to access the quality of water produced. The data used were secondary data obtain from the spreadsheet of the quality control laboratory at the Dalung headworks of the month of December 2016.

The methods of the study were based on the variable of attributes since the study were based on the data obtained from the check sheet of the laboratory.

The Study design were based on the Quality control tools, Quality Assurance, Statistical Process control, control chart Analyses, Accepting sampling and process capability to achieve the set objectives of the study.

Quality control

It is the use of techniques or activities to achieve sustain and improve the quality of a product or service. It involves integrating the following related techniques or activities;

a. Specifications of what is needed.
b. Design of the product or service to meet the full intent of specification.
c. Production or installation to meet the full intent of specification.
d. Inspection to determine conformance to specification.
e. Review of usage to provide information for the revision of specification if needed.

Quality Assurance.

It is all the actions needed/necessary to prevent adequate confidence that a product or service will satisfy a customer's needs. It involves making sure that quality is what should be and this includes a continuous evaluation of adequate and effectiveness with the view of having corrective measure and feedback initiated where necessary.

Quality assurance is involved with activities of control quality as well as the entire quality system. The generic elements of a total quality of a system are;

a. Policy, planning and administration.
b. Design assurance and design change control.
c. Control of purchased material.
d. Production quality control.
e. Corrective action.
f. Employee selection, training and motivations.

Quality assurance is also a way of preventing mistakes or defects in manufactured products and avoiding problems when delivering solutions or services to customers. It is also the administrative and procedural activities implemented in a quality system so that requirements for products are fulfilled. While quality assurance is concerned with defect prevention, quality control deals with defect detection and rejection.

Two basic principles applied in quality assurance are;

a. Fit for purpose – This means the product should be suitable for its intended purpose
b. 'Right first time'- This means that mistakes and errors should be eliminated.

Statistical Process Control (SPC)

This is the systematic method for analyzing process in which monitoring and study of the variation in a production process is done. It is a method of quality control which uses statistical methods.

Statistical process control is a set of problem-solving tools that can be applied to any process. The major statistical process control tools used in the course of the research were;

Check sheet

The check sheet is a form used to collect data or information in real time at the location where the data is generated. The data can be quantitative or qualitative.

Control chart

A control chart is a statistical device used for the study and control of a production process. They are basically used to access the quality of a manufactured product. The chart indicates whether the production process is under control or out of control.

Control Charts Analysis

A process is said to be in statistical control when the process is governed wholly by random causes with assignable causes which are larger in magnitude. The Shewart's control chart analysis is aimed at detecting variation due to assignable causes with the view of eliminating them. Sometimes an operator makes unwarranted machine adjustments during the production process. The control chart helps to indicate when to make useful adjustments and when adjustments are not needed by indicating changes in product quality. A control chart is a powerful tool for controlling and stabilizing process at required performances. It ensures uniformity items throughout the production process.

The method of control chart analysis is to study a set of data. If the variation in the data studied is in agreement with a statistical pattern that might be produced by random causes, then we can safely assume that no assignable cause is present. In that case we say that the condition producing the variation is under control. However, if the variation in the process fail to conform to a statistical pattern that might be produce by chance, we conclude that one or more assignable causes are present, therefore condition is to be "out of control". In other words, the control chart analysis rests on the knowledge of the behavior of random variations. Control chart is also a device used to determine when control has been attained and for attaining control.

Usually in any production process, two kinds of variability exist:

Random or common causes: These are variations that are seen in production process which are caused by nature or random cause. These types of variation cannot be controlled in the production process. But the most important thing about random cause of variation is that it cannot change production quality to an appreciable level. For instance, high temperature resulting in fluctuations of quality of products under process

Assignable or man-made causes: these may arise from these sources: improperly adjusted machine, operator error or defective raw materials. These variations are usually large and are not allowed. The main aim of statistical quality control is to remove all assignable or man-made causes present, hence any process operating in the presence of assignable or man-made causes is said to be "out of control".

Process in control; when all the points plotted on the control chart fall within the control limits the process is in statistical control. This shows that the assignable causes have been eliminated from the process; in that case we expect to attain high degree of uniformity with the existing process. When a process is in control a natural pattern of variation is to have a few points closers to the control limits, majority near the central line and almost equally balance on both sides of the central line. In other words, the distribution of the points follows a normal distribution.

The advantages of process in control are that there will be uniformity of the items produced and cost of inspection is minimizing since few sample will be needed to assess the quality of the product, among others.

Process out of control; when a point is out of the control limits it means that point comes from different process from which the control limits have originally designed. A process may be said to be out of control even when no point falls outside the control limits. This happens when unnatural patterns of variation are found in the process. Like it's unnatural to find seven or more consecutive point fall on one side of CL or have a very large number of points on one side of the CL or have a very low number of points on one side of the CL. This shows a non-normal distribution, also charts showing cyclical trends or upward trends cannot be said to be in control.

There are a lot of rules for detecting or determining if a process is out-of-control. The most common are;

1. The Western Electric rules
2. The Wheeler rules
3. The Nelson rules.

Amongst these, the most common is the Western Electric Rules. The Western Electric Handbook (1956) suggests a set of decision rules for detecting non-random patterns on control charts. These include;

i. One-point plots outside 3-sigma control limits
ii. Two or three consecutive points plot beyond a 2-sigma limit.
iii. Four out of five consecutive points plot at 1-sigma or beyond from the center line
iv. Eight consecutive points plot on one side of the center line.

These rules have been found to be very effective in practice for enhancing the sensitivity of control charts. Consequently, the Western Electric rules are known as run rules for control charts.

Procedure for constructing a control chart for mean, range and standard deviation

a. In the first place, we take samples of size of a month that's 31 days of December at interval of one hour starting from 6am to 5am. Which was obtained as a secondary data in a form of check sheet.
b. Next, we calculated the range, the mean and the standard deviation using the observations obtained at regular interval of 1 hour starting from 6am to 5am daily.
c. We then determine the three lines called the central line (CL), the upper control limit (UCL) and the lower control limit (LCL).

The central line is drawn at the central value; μ_x = E (X)
The upper control limits UCL drawn at CL + 3σ_x
The lower limits LCL is drawn at CL - 3σ_x
σ =√var(x)

d. Then plot the statistics or the observation x_1, x_2……. Against the intervals on a chart in which the CL, UCL and LCL have been drawn.

If a point falls outside the UCL or LCL then we conclude that the process is out of control and should be stopped. The causes must be identified and corrected before the process is resumed.

Types of Control Charts

There are basically two types of control charts. Just like how the quality of a product can be expressed as either by variables or attributes, so it is for control charts.

Control Chart for Variables

The control chart for variables that are most frequently used are the mean, the range and the standard deviation which was used in the study

The mean chart($\bar{X}-charts$)

The mean chart show variation in sample means and is used for the control of process level.

It is computed as follows;

For a given sample, the mean ($\bar{x}$) is derived through; $\bar{X}$=ΣXi, =1, 2, 3,…,$herenissamplesize$.

The Range (R) =$X_{MAX} - X_{MIN}$
The mean range ($\bar{R}$) is given by; $\bar{R} = \Sigma Ri$, i=1, 2, 3,,.
The control limits of $\bar{X}-charts$ are given by; $UPPERCONTROLLIMIT = \bar{\bar{X}} + A2\bar{R}$
$LOWERCONTROLLIMIT = \bar{\bar{X}} - A_2\bar{R}$
$A_2$is derived from a statistical Table. It is also dependent on n, the sample size.
When the standard deviation (σ) and mean (μ) is given, then $\bar{X}$-chart is computed as follows:
UPPER CONTOL LIMIT= $\mu + 3\sigma\sqrt{n}$
LOWER CONTROL LIMIT= $\mu - 3\sigma\sqrt{n}$

The Range Chart (R-chart)

This chart is used to monitor the amount of variability around the process level. Like the $\bar{X}$ chart, the R-chart also contains a center line and upper and lower control limits. The lower limit is bounded by zero and sometimes turns out to be zero. The R-chart is constructed as follows;

a. If σ is known, then the center line is σ.
UPPER CONTROL LIMIT=$D_2\sigma$
LOWER CONTROL LIMIT= $D_1\sigma$
Here the unbiased estimate for $\sigma = \bar{R}d_2$

b. If σ is unknown, then the center line is $\bar{R}$ and the control limits are;
UPPER CONTROL LIMIT=$D_4\bar{R}$
LOWER CONTROL LIMIT=$D_3\bar{R}$
The coefficient D_4 and D_3 are derived from a statistical table and dependent on the sample size, n.

Control Charts for Attributes

These are used when qualitative data are obtained which are measured as defective or non-defective. In this case mean and range chart cannot be used and hence control chart of attributes used Includes;

i. Control charts for proportion of defectives (p-chart)
ii. Control charts for number of defectives (np-chart)
iii. Control charts for number of defects (c-chart)
iv. Control charts for number of defects per items (u-chart)

Acceptance Sampling

Acceptance sampling refers to the application of specific sampling plans to a designated lot or sequence of lots. It is also the process sampling inspection used to decide whether to accept or reject a lot of good on the basis of predetermined standards. Advantages of acceptance sampling as opposed to hundred percent inspection include;

i. Less handling damage during inspection.
ii. Fewer inspectors, thereby simplifying the recruiting and training problem.
iii. Upgrading the inspection job from piece-by-piece decisions to lot-by-lot decisions.
iv. Applicability to destructive testing, with a quantified level of assurance of lot quality.
v. Rejections of entire lots rather than mere return of the defectives, thereby providing stronger motivation for improvement.

Some disadvantages of acceptance sampling are;

- There are risks of accepting 'bad' lots and rejecting 'good' lots.
- There is added planning and documentation.
- The sample usually provides less information about the product than hundred percent inspections do.

Process Capability

Process capability is a measurable property of a process to the specification, expressed as a process capability index or as a process performance index. The capability of a process can only be determined after control charts have been monitored and deemed to be in statistical control. If a process is out of control, then the capability has no meaning at all. Therefore, the process capability involves only chance or common cause variation and not assignable cause variation.

Process capability therefore refers to the ability of a process to stay within its specification limits. Two graphical tools, the tolerance chart (tier chart) and the histogram, are helpful in assessing process capability. Process capability Cp define $by\ USL - LSL6\sigma$.

The computation of Cp is based on the following assumptions;
1. The process output is normally distributed
2. The process output is normally distributed within specification.
3. The process is stable (under control).

If Cp <1, the process is not capable of operating within the specification limit.
If Cp =1, the process is just capable of operating within the specification limit
If Cp >1 then the process is highly capable operating within the specification limit

Subgroups

Formation of rational subgroups is key to successful control charts. Control charts rely on rational subgroups to estimate the short-term variation in the process.

A rational subgroup is simply a sample in which all of the items are produced under conditions in which only random effects are responsible for the observed variation. A rational subgroup is also one in which the system of causes influencing within subgroup variation is equivalent to the system of causes influencing between subgroup variation.

Rational subgroups are selected so that if process changes of practical importance exist, the chance that these changes will occur between subgroups is maximized and the chance that these changes will occur within subgroups is minimized.

3. INDICATORS USED AND MODEL SPECIFICATION

The indicators that was used were PH, Color turbidity in three stages of the processing levels of the water that's raw water stage, filtrations stage and final water stage of the data obtained from the dalung headworks of the Ghana water company.

PH

In its guideline, no health-based guideline value is given for pH. This is because, according to WHO, pH is not of health concern at levels found in drinking water. However, it suggests a pH of between 6.5 and 8.5.

Color

Water naturally has no color. Water can get color from its container, from the presence of colored organic matter, or from iron and other metals. Color is measured in True Color Units (TCU). No specific health-based guideline value is given by WHO for color in drinking water.

However, consumers usually do not accept color levels above 15TCU, since this suggests presence of organic matter.

Turbidity

Turbidity is the relative clarity of a liquid. Turbidity is a measure of light transmission in water. It is caused by suspended particles or matter that obstructs light transmission through water. Materials that cause water to be turbid include clay, silt, organic and inorganic matter. Excessive turbidity is a serious health concern, since it provides food and shelter for disease-causing organisms. Turbidity is measured by Nephelometric Turbidity Units (NTU). Turbidity can be noticed by the naked eye above approximately 4.0 NTU. WHO suggest that turbidity should be not more than 1 NTU and preferably much lower. It encourages large supplies to achieve less than 0.5 NTU. WHO further suggests a maximum of 5 NTU with a goal for 1 NTU for small supplies lacking resources.

4. METHOD OF DATA ANALYSIS

The control chart of attributes was used since we were dealing with numeric data in which analysis were performeds on the indicators used in that's pH, color and turbidity in the three stages of the water process that were considered

Range chart and Mean chart were performed in all of the indicators in each stage with the aid of Spss and excel.

With the PH range chart, mean chart and process capability were performed in all of the three stages of the processing stages that's raw water, filtrated water and final water stage.

More so with the color the range chart, mean chart and process capability were also performed in all of the three stages of the processing levels.

And with the turbidity also range chart, mean chart and process capability were performed in all of the three stages of the processing levels.

Ethical consideration

The study was conducted based on a secondary data obtained from the Dalung headworks of the Ghana water company of the month of December 2016 spread sheet.

5. RESULTS

Looked at the three indicators that were used that's PH color and turbidity of the water processing stages that's raw water stage, filtered water stage and final water stage. As shown in the figures and tables it was observe that the range chart which talks of the variability of the chart using the sample ranges to monitor the spread of all the indicators were statistical out of control meaning the mean chart is also going to be automatically out of control because the mean chart uses the sample of the ranges to calculate its means.

Which indicated that per the WHO organization standards that were used the water produced at the Dalung headworks were not wholesome for consumption.

6. STAGES OR STEPS OF THE PROCESSING

The first stage in the water treatment process at the Dalung Waterworks is the damming or impoundment. This is where a barrier is created to serve as a reservoir for raw water from the White Volta (nawuni).

Then the screens stage; where a strainer is used to separate relatively heavy solid particles like leaves, stones, rocks or large debris from the water. We have the macro and minor screening. Only macro screening is done at the treatment plant.

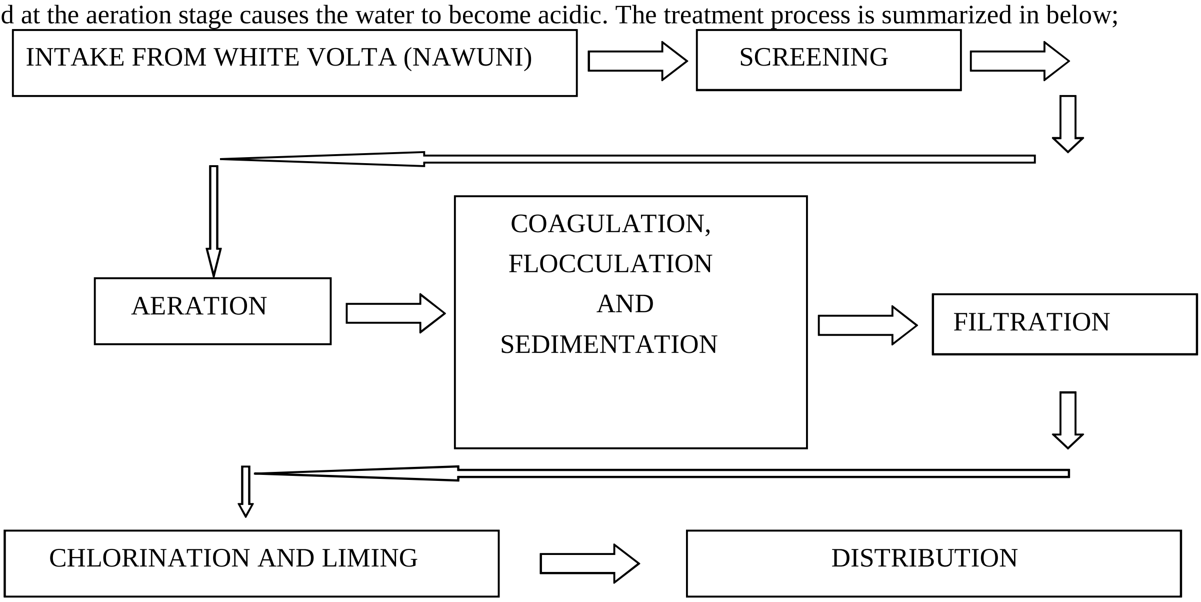
The third stage is the aeration stage. Aeration is a process by which air is circulated through a substance. Here, an aerator is used to remove odor and carbon dioxide from water. Alum (Aluminum Sulphate) is added at this stage.

The next stage is where up to eighty (80) percent of impurities are removed from the water. It is the coagulation, flocculation and sedimentation stage. The aluminum Sulphate added at the aeration stage causes the small suspended particles or solids which were not removed at the screening stage, to clump together or coagulate, to form larger groups of particles called flocs. These larger particles then settle at the bottom of the water. Here, the flocs are removed from the base of the sedimentations tanks very slowly and mechanically. The sedimentation process is sometimes called clarification.

Next is the filtration stage. The filtration stage removes suspended matter, which could include flocs and microorganisms. Water is passed through a layer of sand and these particles are filtered, and remain on top of the sand. This process reduces the turbidity of the water.

After filtration, the next stage is chlorination. Chlorine gas is added to the water here to removing any remaining disease-causing organisms which may still be present in the water. Care is taken here on the right proportion of chlorine gas to use. Too much chlorine gas provides a haven for growth of pathogens in the distribution process.

Lastly, Lime is added to the water to raise its PH. This is important because the alum (aluminum sulphate) added at the aeration stage causes the water to become acidic. The treatment process is summarized in below;



7.CONTROL CHART ANALYSIS ON THE INDICATORS

Among the three indicators used these where the analysis

PH

Raw water stage

The R chart which talks of the variability of the chart using the samples ranges to monitor changes in the spread of the process.

In Fig 4.1 in the appendix it was clearly shows that the process is out of control because some of the points where found outside the UCL and the LCL and hence the is no need examining the X bar chart since the X bar chart uses the sample means of the range to monitor changes in the location of the process.

But notable the above result was expected since the water is still at the raw state and that no treatment is applied to it at this point.

But because of clarity and detailed analyses we will still throw more light on the X bar chart to ascertain our claim with regards to the rules of statistical quality control. Which will apply to all the stages of the indicators.

In Fig 4.2 in the appendix it was observed that the process was out of control because the points where found out of the specified control limits that’s the UCL and the LCL and hence the process were statistical out of control hence we can conclude that the process where statistical out of control meaning at this stage of the production the water is not wholesome for consumption.

Settled stage

In Fig 4.3 in the appendix the R chart it was observed that the process where statistical out of control because most of the points where out of the control limits that's the UCL and LCL hence the X bar chart was not needed but because of clarity seek we had to perform it to ascertained our fact.

In Fig 4.4 in the appendix the X bar chart it was observed that the process where out of control because most of the points fall out of the specified limits that's the UCL and LCL hence the process where statistical out of control and hence at these stages the water was not wholesome for consumption.

Final water stage

In fig 4.5 in the appendix the R chart it was observed that the process where statistical out of control because most of the points where out of the specified control limits that's the UCL and the LCL and hence we performed the X bar chart which were not supposed to be performed due to the R chart to ascertained our claim about the R chart.

In fig 4.6 in the appendix the X bar chart it where observed that the process where statistical out of control because some of the points where out of the specified limits that's the WHO specification of the UCL and LCL used and hence the process where statistical out of control meaning the water were not Wholesome for consumption.

TURBIDITY

Raw water

In Fig 4.7 of the appendix the R chart it was observed that the control chart were out of control because some of the points where fall below or above of the specified limits that's the UCL and the LCL and hence the process where statistical out of control.

In Fig 4.8 of the appendix the X bar chart were not supposed to be performed due to the R chart been out of control but was done to ascertained our claim about the R chart which it was observed that the process where out of control because some of the points fall out of the UCL and the LCL and hence the process were statistical out of control meaning the water were not wholesome for consumption.

Settled water stage

In Fig 4.9 in the appendix it was observed that at the control chart analysis it was observed that the R chart were statistical out of control because some of the points were out of the control limits that's the UCL and the LCL that automatically makes the X bar chart out of control indicated in Fig 4.10 of the appendix and hence the water was not wholesome for consumption.

Final water stage

In Fig 4.11 in the appendix it was observed that the process where out of control because some of the points were out of the specified limits that's LCL and UCL hence the X bar chart is automatically out of control hence the water is not wholesome of consumption at these stages as indicated in fig 4.12 of the appendix.

COLOUR

Raw water range

In Fig 4.13 in the appendix it was observed that the R chart were out of the control limit that's the LCL and UCL and hence the X bar chart automatically becomes out of control because it uses the variability of the R chart points in measurements as indicated in fig 4.14 and hence the water was not wholesome for consumption since the process is statistical out of control.

Settled Water range

In Fig 4.15 in the appendix it was observed that the R chart was statistical out of control because some of the points was out of the specified limits that's the UCL and LCL and hence the X bar chart of the control chart automatically becomes out of statistical control as indicated in fig 4.16 of the appendix and hence the water is not wholesome for consumption.

Final water stage

In Fig 4.17 of the appendix it was observed that the process where statistical out of control because some of the points where out of the specified limits that's the UCL and the LCL and hence the X bar chart will also be automatically out of control because it uses the variability of the R chart to monitor its activities as indicated in fig 4.18 of the appendix and hence the water at these stages was not wholesome for consumption.

NB: the most important indicator that determines wholesomeness of water consumption is turbidity.

8. DISCUSION

The main purpose of the study was to determine the quality of water produced by the GWCL of the Dalung Headworks of which three indicators where used at the three stages of the processing levels.

After the study it came to realizations that all the indicators at various stages of the water were statistical out of control and also variability was also very large from stage to stage according to the control chart analyses meaning production didn't met the required standard and hence the water were not wholesome for consumption.

9. CONCLUSION

With detailed and in-depth analysis performed on the water production process at the Dalung Headwork's in the northern region, using quality control tools, it was concluded that all parameters at all three stages used in the analyses of the production felt out of approved control limits and are therefore deemed to be in an out of control state, hence the process was statistically out of control.

These means that variations due to assignable causes ware very large relative to random or unavoidable causes of variation. It can also be concluded based on results and findings from the control charts used, that treated water from the Dalung Headwork's in the northern region is of low quality and improvements must be done to remove all avoidable or assignable causes of variations. These causes may include; defective raw material (source of the raw water), improperly adjusted machines (PH scale, Nephelometric Turbidity units and TCU device) and operator errors.

X bar chart violation rule was also used to confirm the R chart claim, because we would have disregard it since the R chart was statistically out of control in all the three stages and their indicators which was used in it mean's in calculation of X bar chart and Process Capability was used not to perform any analyses but for clarity because it can only be applied to processes that were already in statistical control.

10. RECOMMENDATIONS

- The Quality Control Laboratory of the Dalung Headwork's is encouraged to use statistical quality control tools such as control charts to effectively identify assignable causes in the production process and subsequently take measures to remove them.
- Since quality control aims at 'building quality into a product the first time', employees at various stages of production must be properly supervised and given the needed attention.
- Periodic in-house capacity building workshops and training on new and improved methods of production should be taught to workers, instead of relying on what they learn from their other employees. This reduces variability and improves quality.
- Management should not be satisfied with current levels of quality and the production process should be gradually, but constantly improved using statistical methods.

11. REFENCE

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12. APPENDIX

PH

Fig 4.1 R chart of raw water

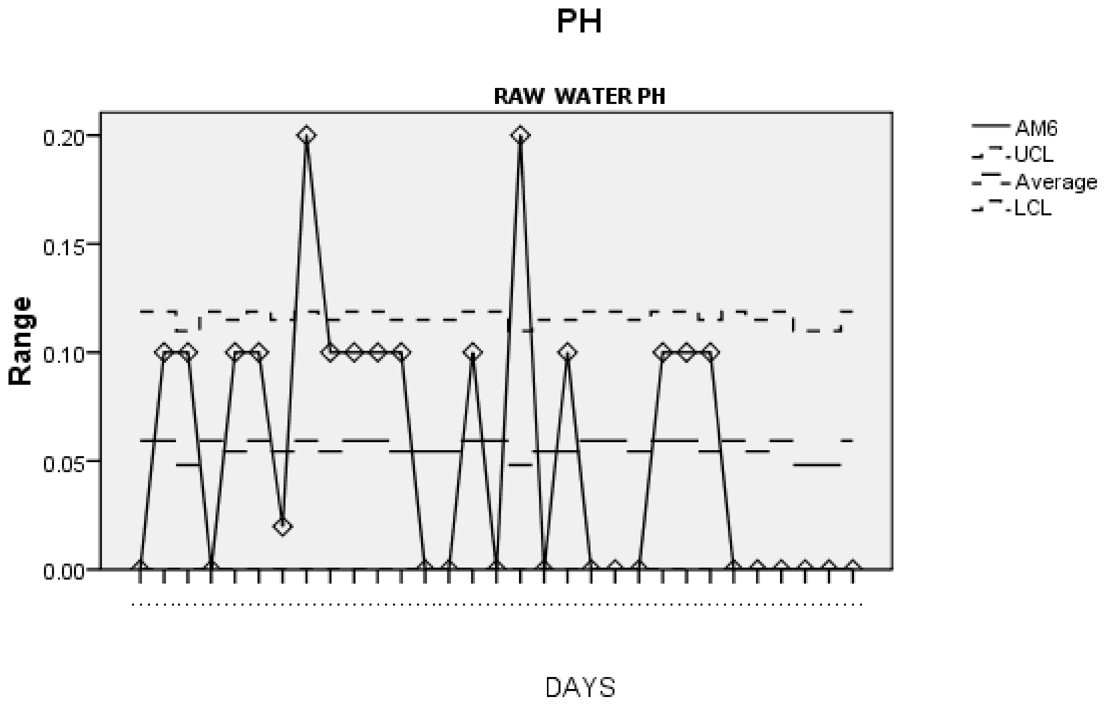
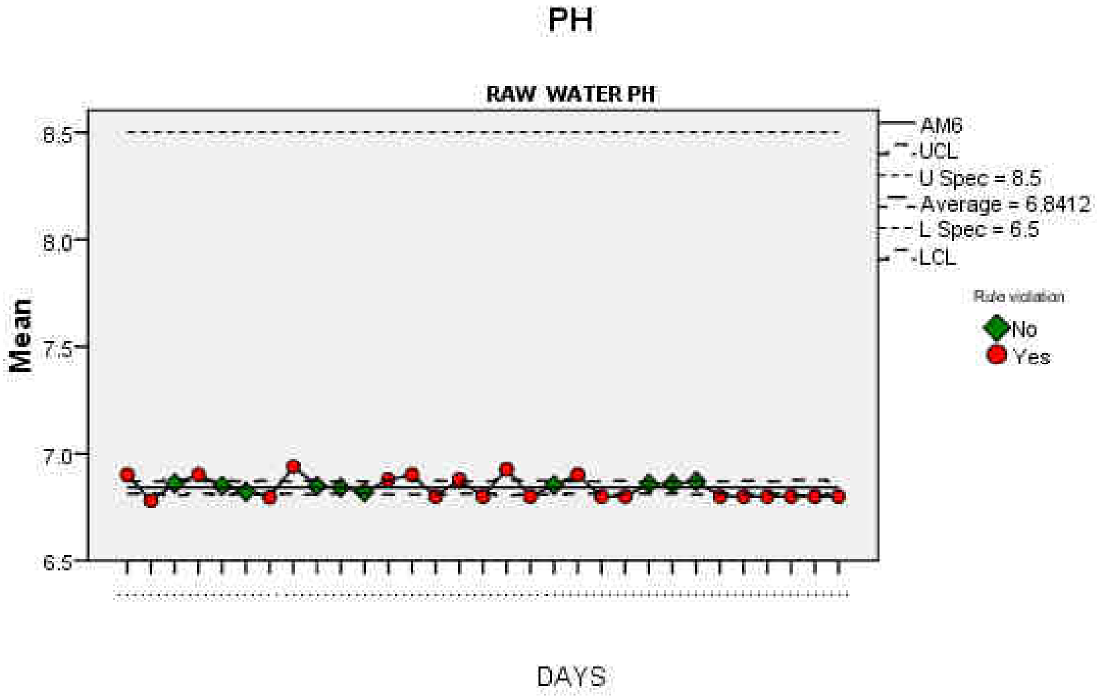


Fig 4.2 X bar chart of raw water



SETTLED WATER

Fig 4.3 R chart of raw water PH

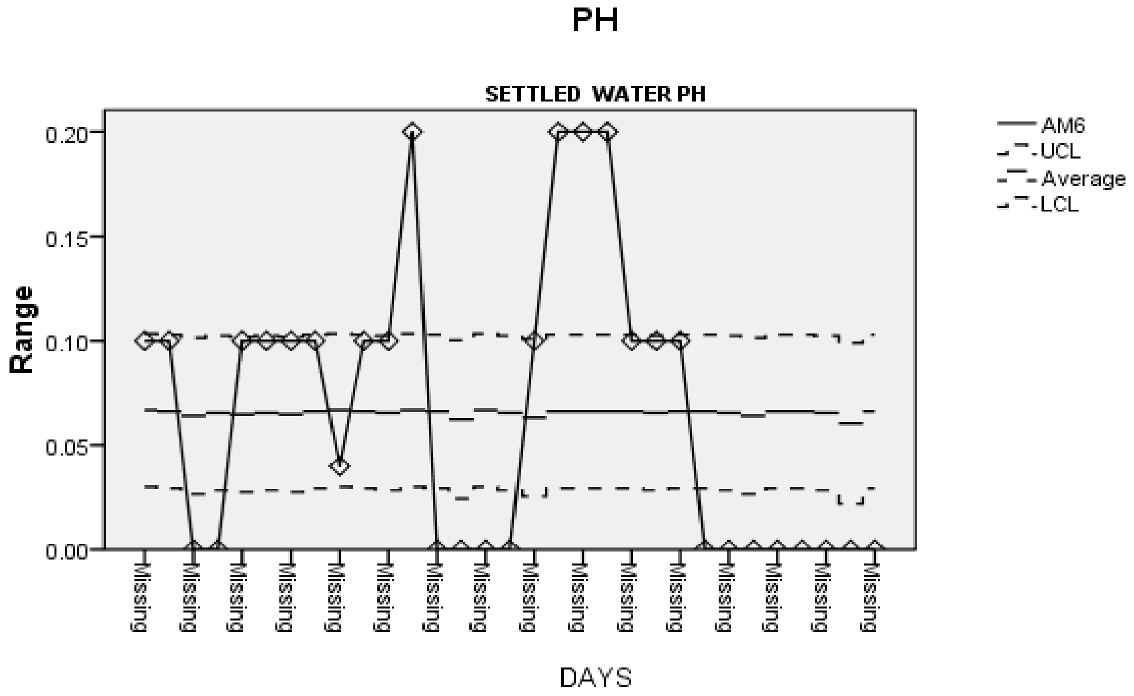


Fig 4.4 X bar chart of settled water PH

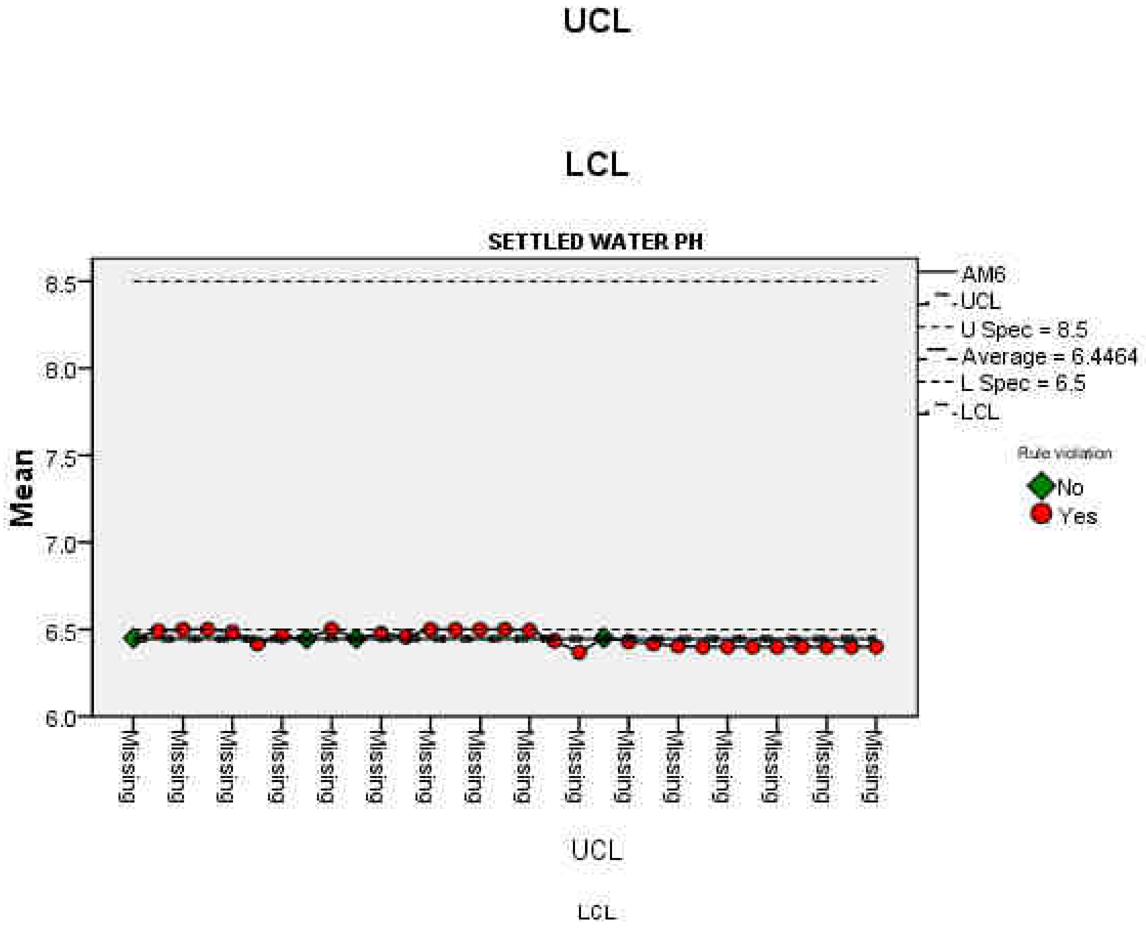


Fig 4.5 R chart of final water stage PH

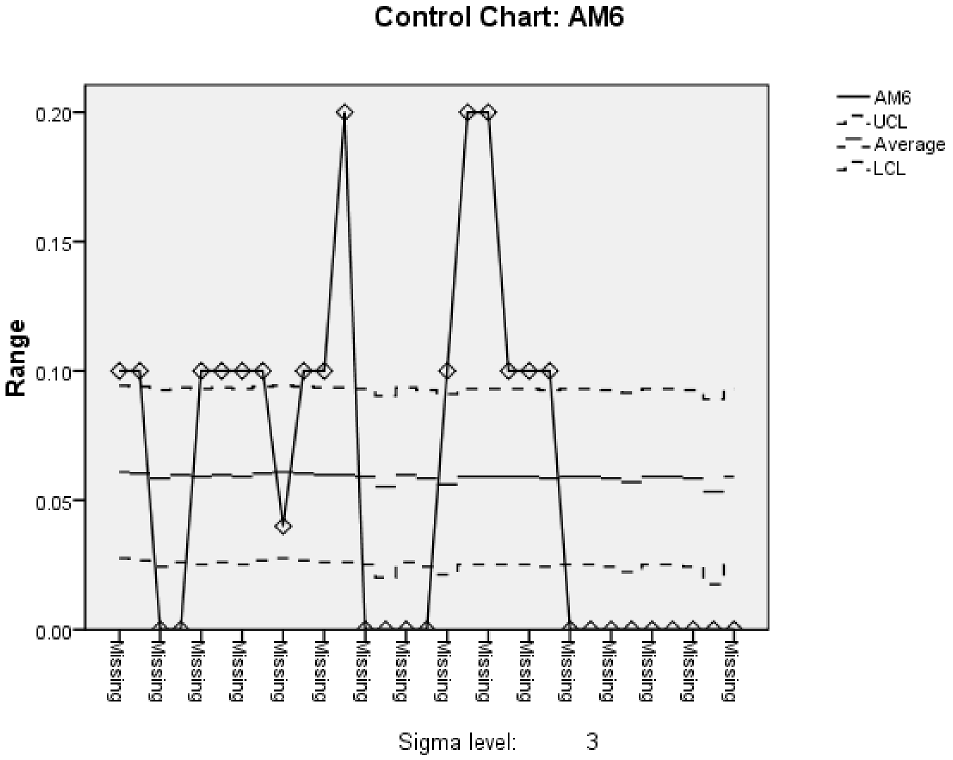
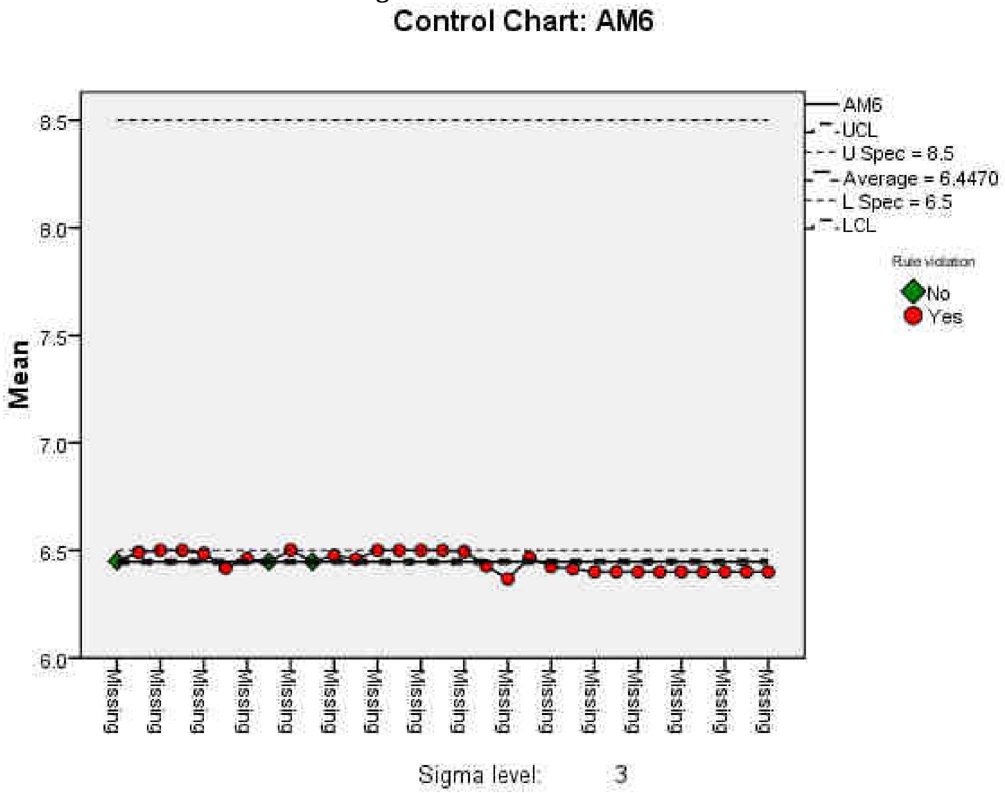

Control Chart: AM6

Fig 4.6 X bar chart of final water stage PH


Control Chart: AM6

TURBIDITY

Fig 4.7 R chart of raw water stage Turbidity

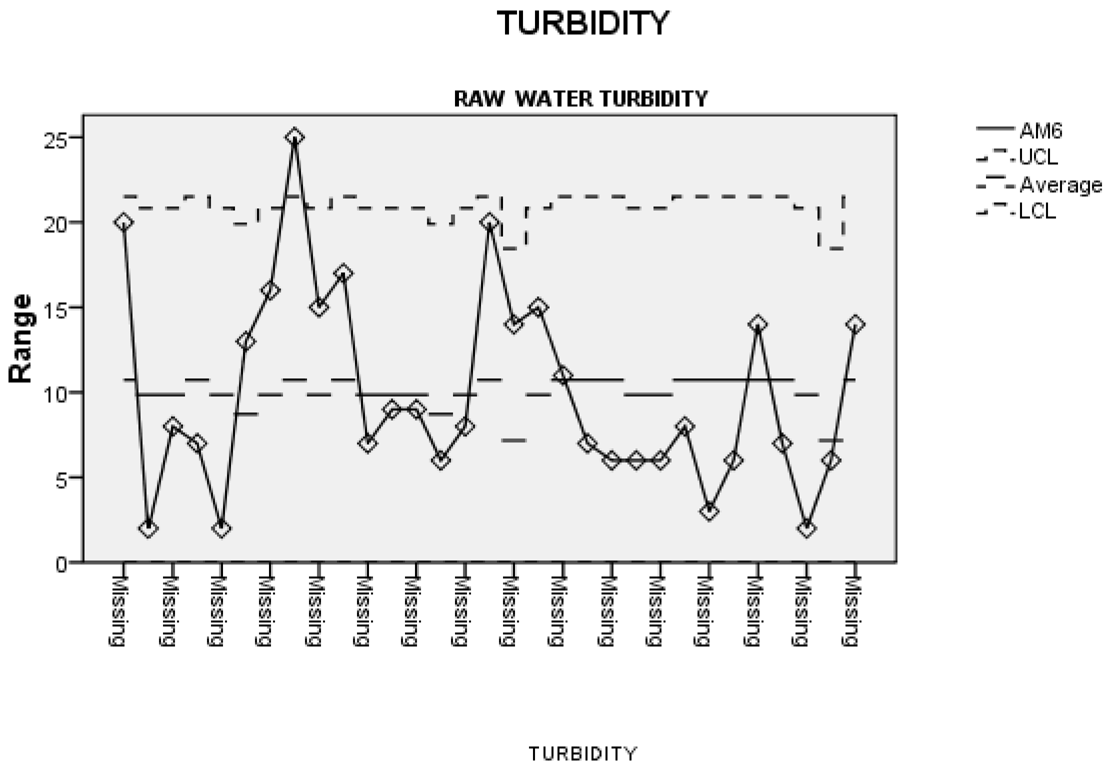


Fig 4.8 X bar chart of raw water Turbidity

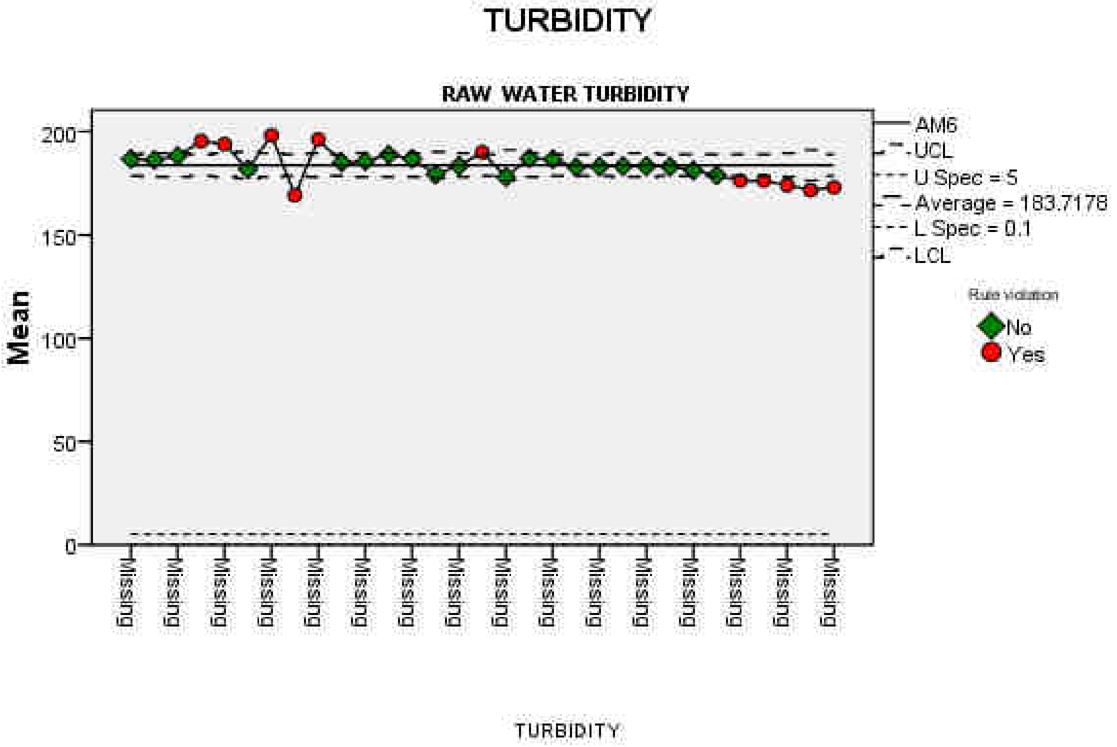


Fig 4.9 R chart of settled water Turbidity

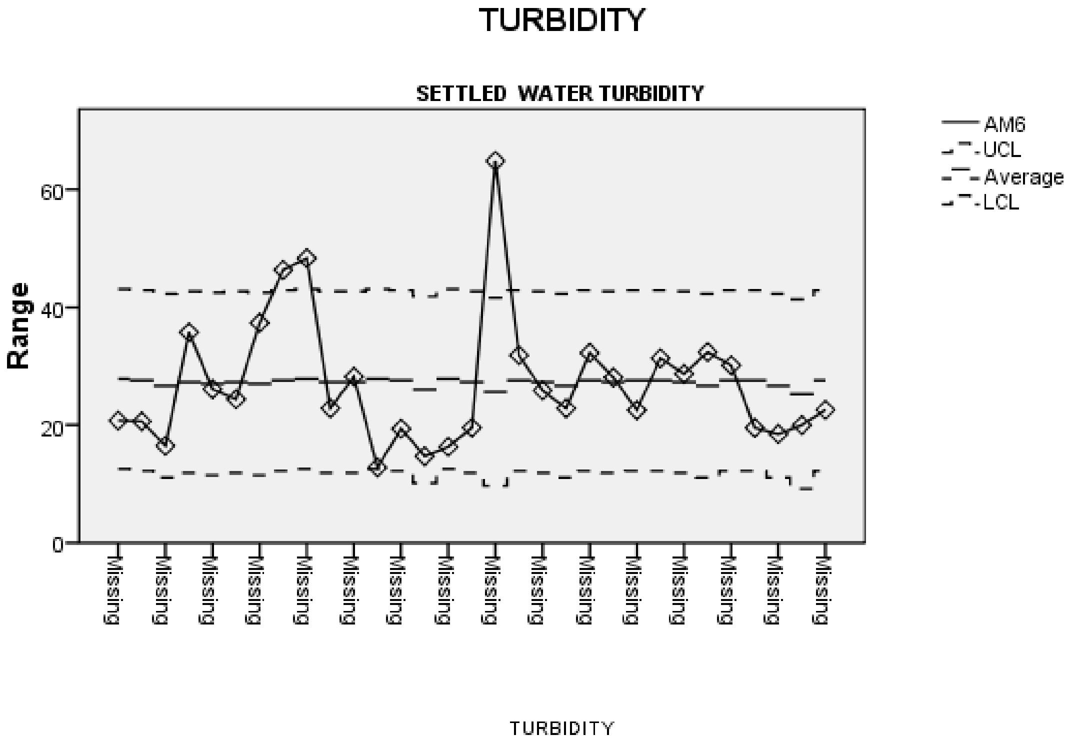


Fig 4.10 X bar chart of settled water Turbidity

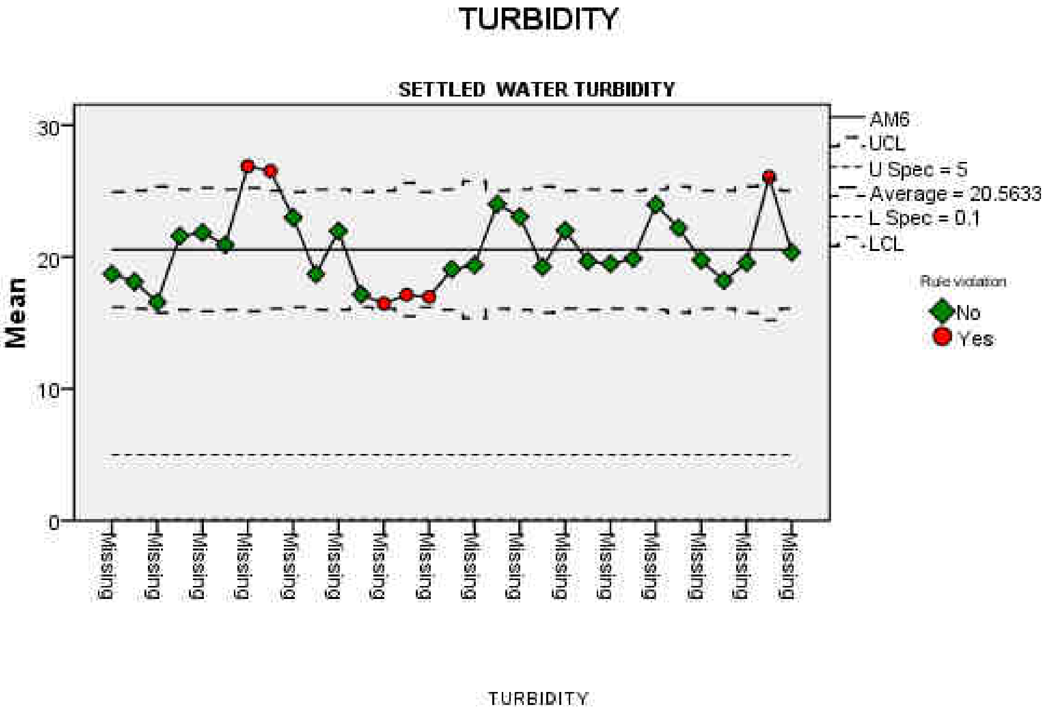


Fig 4.11 R chart final water Turbidity

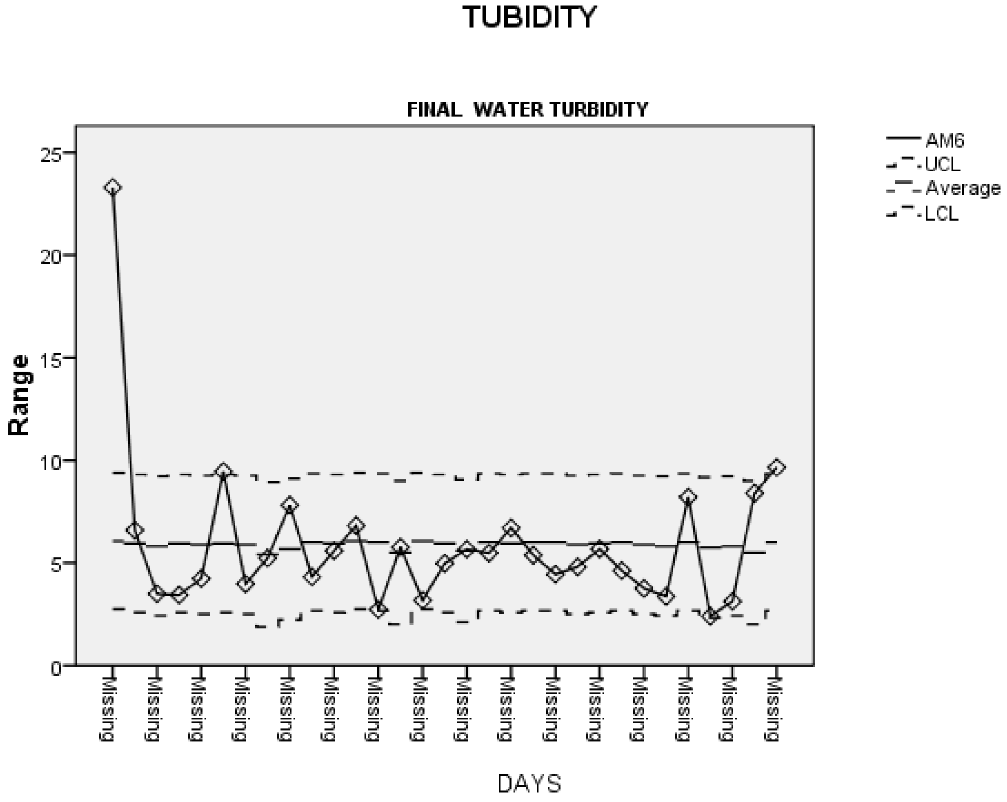
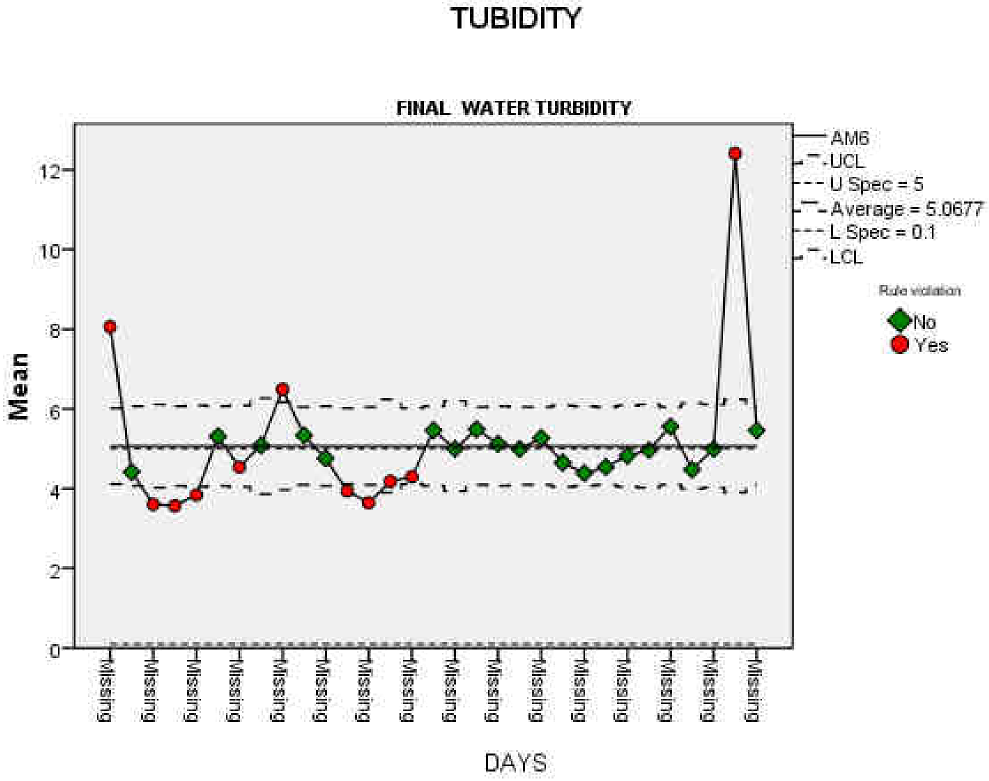


Fig 4.12 X bar chart of final water Turbidity



COLOUR

Fig 4.13 R chart of raw water color

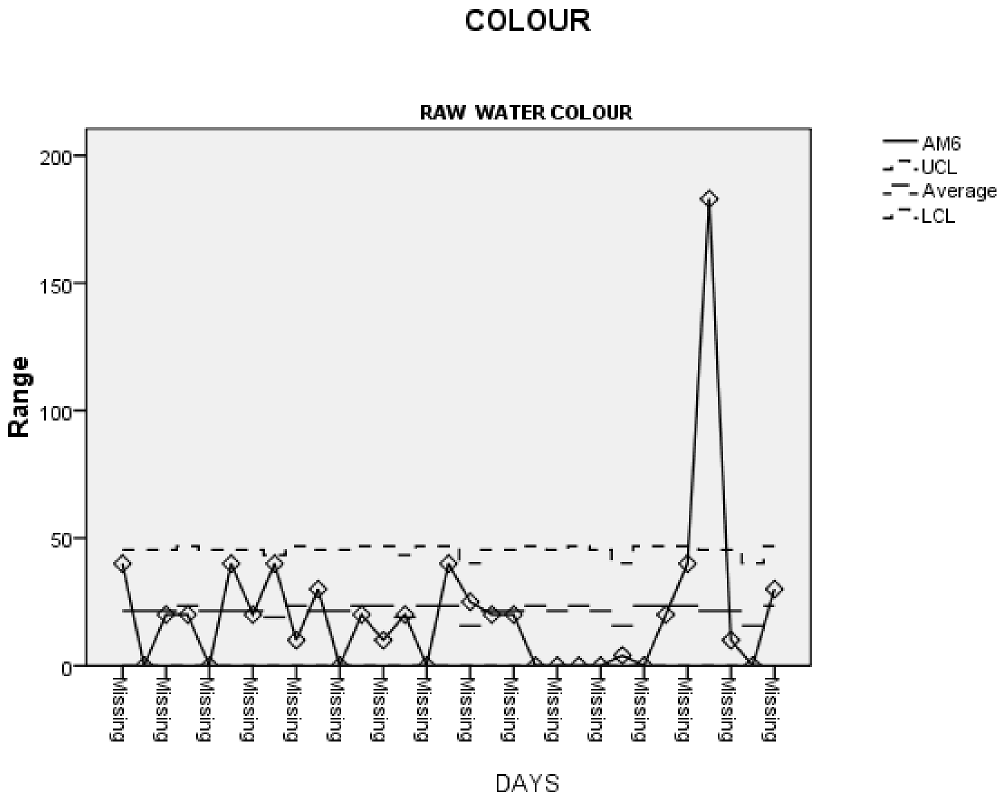


Fig 4.14 X bar chart of raw water color

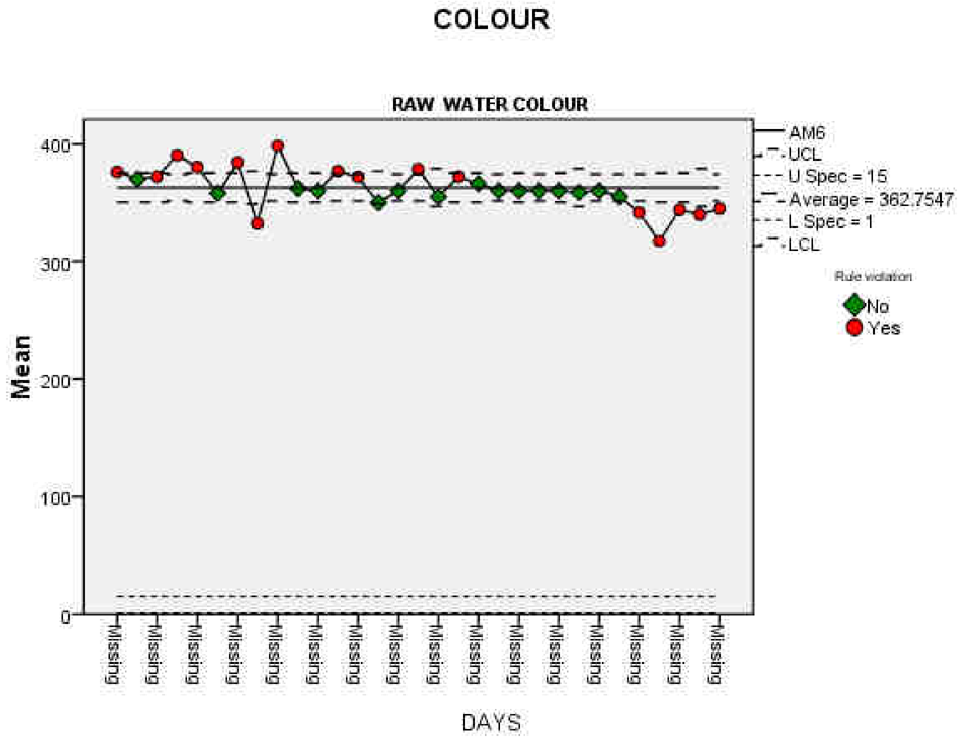


Fig 4.15 R chart of settled water Color

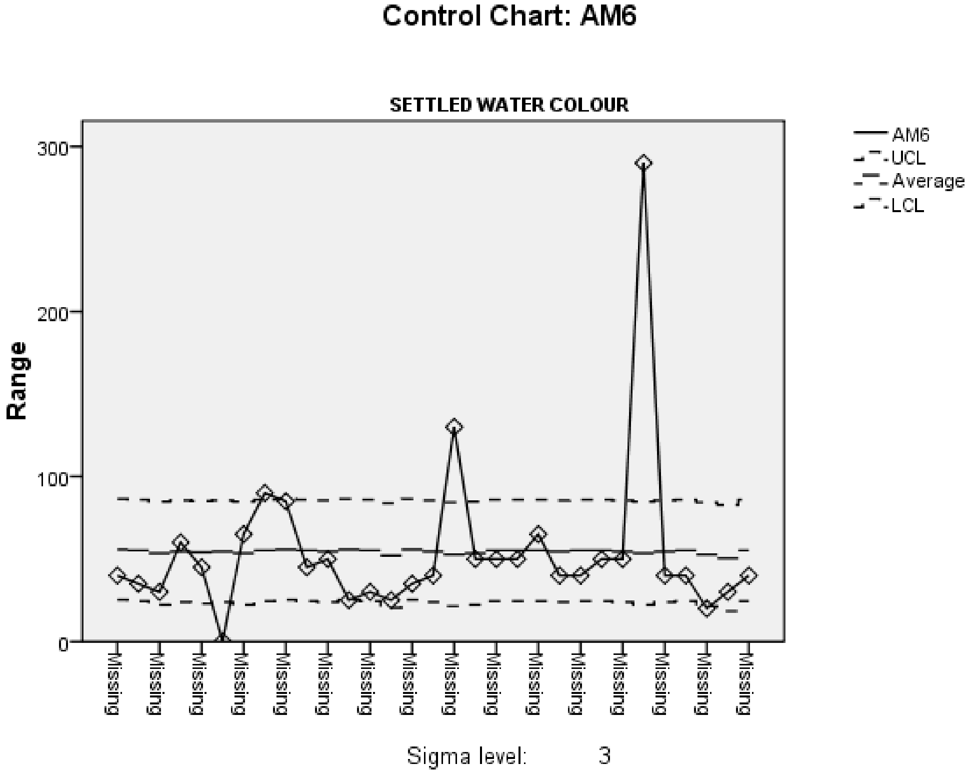
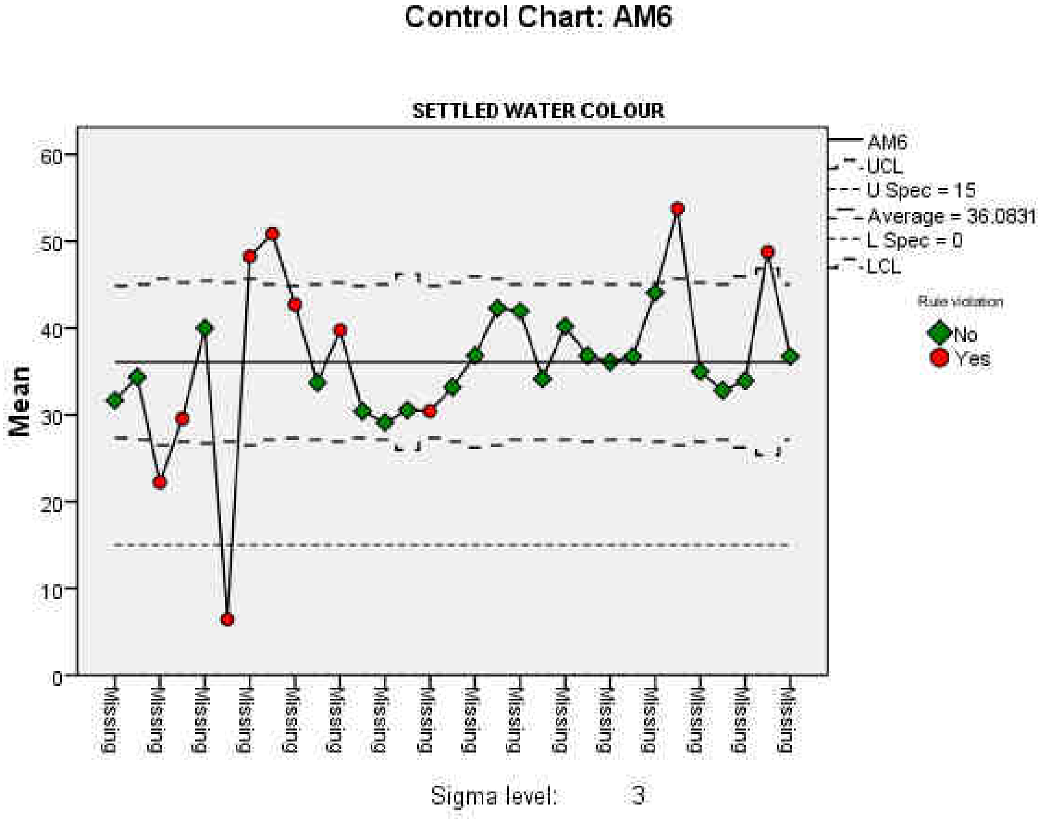


Fig 4.16 X bar chart settled water Colour



FINAL WATER COLOUR

Fig 4.17 R chart of final water Colour

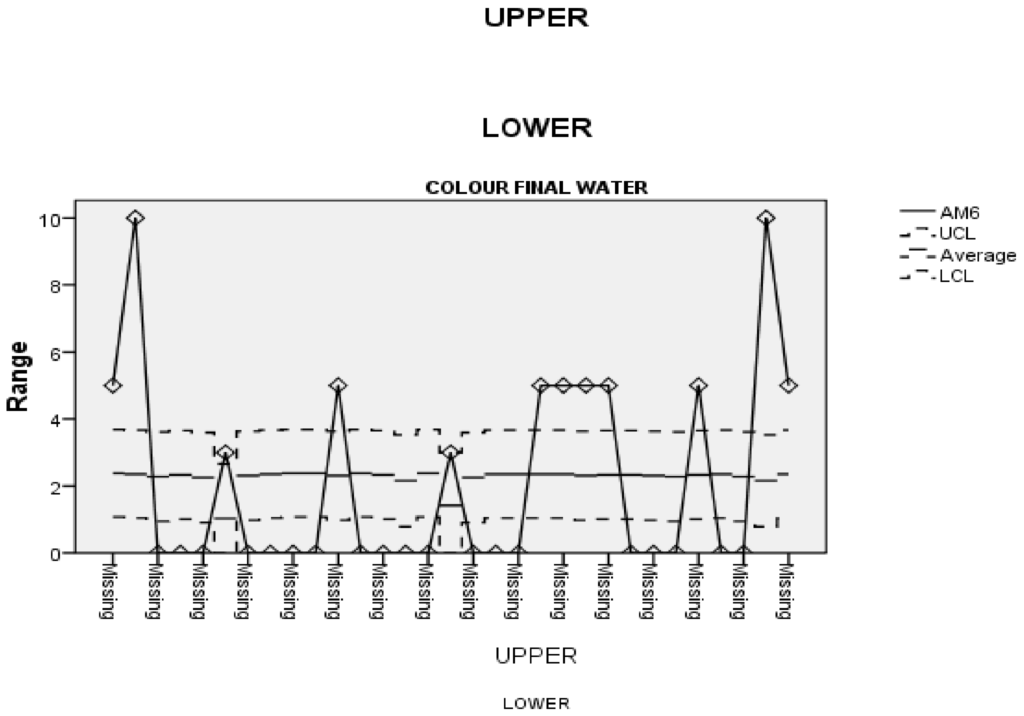


Fig 4.18 X bar chart of final water colour