Improvement of Water Distillation Plant by Using Statistical Process Control System

Qasim Kriri, Harsh B. Desai

***Abstract*—**Water supply and sanitation in Saudi Arabia is portrayed by difficulties and accomplishments. One of the fundamental difficulties is water shortage. With a specific end goal to beat water shortage, significant ventures have been attempted in sea water desalination, water circulation, sewerage, and wastewater treatment. The motivation behind Statistical Process Control (SPC) is to decide whether the execution of a procedure is keeping up an acceptable quality level [AQL]. SPC is an analytical decision-making method. A fundamental apparatus in the SPC is the Control Charts, which follow the inconstancy in the estimations of the item quality attributes. By utilizing the suitable outline, administration can decide whether changes should be made with a specific end goal to keep the procedure in charge. The two most important quality factors in the distilled water which were taken into consideration were pH (Potential of Hydrogen) and TDS (Total Dissolved Solids). There were three stages at which the quality checks were done. The stages were as follows: (1) Water at the source, (2) water after chemical treatment & (3) water which is sent for packing. The upper specification limit, central limit and lower specification limit are taken as per Saudi water standards. The procedure capacity to accomplish the particulars set for the quality attributes of Berain water Factory chose to be focused by the proposed SPC system.

***Keywords*—**Acceptable quality level, statistical quality control, control charts, process charts.

I. Introduction

THE purpose of SPC is to determine if the performance of a process is maintaining an AQL. By using the appropriate chart, management can determine if changes need to be made in order to keep the process in control. The company targeted is a sea water distillation plant. The plant is situated in Saudi Arabia. As we know, there is high scarcity of drinking water in gulf countries; therefore, they majorly depend on distilled water for drinking purpose. An attempt is made to optimize the distillation process in the plant to increase the quality of the drinking (distilled) water. The issue for this venture viewed as a viable arrangement is the fluctuation of the estimations of the quality attributes of the plant's item. It is substantial that outcomes in low process abilities which, thus, prompt bring down efficiency. The undertaking destinations have been received to wipe out the fluctuation of the quality attributes of the item and enhancing the procedure abilities at chose purposes of control. Three purposes of control were first chosen; the sustain water (at the origin), the pervade water (after the treatment), and the last product (after the filling operation). Two quality attributes were recognized as the most essential details; the TDS and pH. One example is taken each hour at the main purposes of control. For this, x and moving charts (I-MR diagrams) have been set up and overhauled. At the last item of control, three specimens are taken each hour. For this, X bar and R outlines have been built up and re-examined. Minitab programming has been used to find results of X bar and R outlines. Process capacities have been measured and found in moderately low estimations of the lists Cp and Cpk. In any case, the sum total of results has been examined with Berain staff and restorative activities have been proposed and put in experimentation. Subsequent to honing the recommended restorative activities, new control outlines have been created and new estimations of process capacity files got demonstrating critical enhancements in the process ability at the purposes of control. Efficiency of creating Statistical Process Control (SPC) system is achievable as an answer of the focused-on issue could be finished up.

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II. Literature Review

Control charts are an extraordinary procedure for critical thinking and the subsequent quality change. Quality change happens in two circumstances: First, at the point when a control graph is first presented and the procedure as a rule is shaky. As assignable foundations for unstable conditions are distinguished and remedial move made, the procedure ends up plainly steady, with a subsequent quality change. The second circumstance concerns the testing or assessment of thoughts. Control charts are incredible chiefs on the grounds that the example of the plotted focuses will decide whether the thought is a decent one, poor one, or has no impact on the procedure. On the off chance that the thought is a decent one, the example of plotted purposes of the X bar diagram will focalize on the central line, X0. As it were, the example will get nearer perfection, which is the central line. For the R diagram and the attribute charts, the example will tend to zero, which is near perfect. These change designs are shown in Fig. 1. On the off chance that the thought is a poor one, an inverse example will happen. Where the example of plotted focuses does not change, at that point the thought has no impact on the procedure.

Varieties in the process that may influence the nature of the item can be identified and revised, accordingly lessening waste as well as the probability that issues will be passed on to the customer. SPC is an analytical decision-making device which enables to see when a procedure is working accurately and when it is not. Variety is available in any procedure, choosing when the variety is common and when it needs adjustment is the way to quality control [1]. With its accentuation on early location and counteractive action of issues, SPC has a particular favorable position over other quality techniques. Three purposes of control were first chosen; the sustain water (at the origin), the pervade water (after the treatment), and the last product (after the filling operation). At the point when a procedure is considered wild, an alert is raised, with the goal that specialists can search for assignable reasons for variety and attempt to dispose of them [2]. It is more powerful to take a proactive way to deal with keep the event of out of control circumstances enabling the procedure to be balanced in a preventive way with the goal that less non-conforming products will be produced.

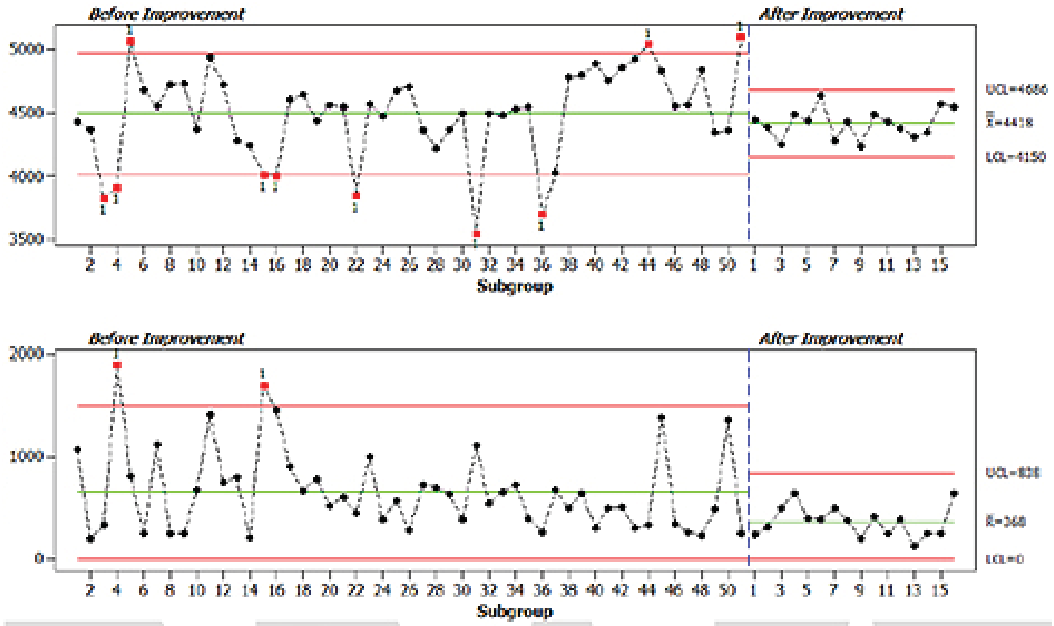

Fig. 1 Before & After Improvement (X Bar-R Chart)

A. Capability Index (C_{pk})

The capability index does not measure process performance with respect to the nominal or central value. This measure is fulfilled by C_{pk}, which is denoted by;

$$C_{pk} = \frac{Min\{(USL - \overline{X})\ or\ (\overline{X} - LSL)\}}{3\sigma} \quad (1)$$

B. Creating Charts Based on Data

Charts are feasible to use only when one or two factors of the quality characteristics are taken into consideration. The process of using charts is very time consuming, lengthy and sometimes expensive. So, improvement of quality on the basis of chart method is very rare, but effective in some situations.

C. Consideration of Quality Factors & Control Points

The two most important quality factors in the distilled water which were taken into consideration were pH and TDS. There were three stages at which the quality checks were done. The stages were as follows; (1) Water at the source, (2) water after chemical treatment & (3) Water which is sent for packing. The upper specification limit, central limit and lower specification limit are taken as per Saudi water standards. The Saudi Standards, Metrology and Quality Organization's prescribed limits are shown in Table I.

We got these constraints for pH and TDS from Saudi Standards, Metrology and Quality Organization (SASO). These impediments in the vicinity of 6.5 and 8.5 for pH and in the vicinity of 100 and 500 for TDS which is acknowledged as a safe delivered, however they eager to be in target which is 7.5 for pH and 150 for TDS. The varieties are common things at any generation procedure, however we can decrease it by various routes; one of them is SPC.

TABLE I
SPECIFICATION LIMITS OF WATER QUALITY CHARACTERISTICS [3]

	pH	TDS
Lower Specification Limit, LSL	6.5	100
Target Value	7.5	150
Upper Specification Limit, USL	8.5	500

III. PROBLEM STATEMENT

The selected distillation plant is facing a severe problem, as it fails to reach the target value of the various constituents in the packaged drinking water. As the percentage of the required and added constituents exceeds the specification limits, drinking water gets unfit for consumption. Thus, the whole batch has to be discarded. This leads to wastage of multiple resources of the company (including money, time etc.). This is a major loss to the company. The main objective is to reduce the wastage of resources, by implementing proper quality improvement techniques. If we get the percentage of the added constituents within the control limits, specified by SASO, it can help the company from baring huge loss, which is invested on its product manufacturing.

IV. Methodology

The framework created for the study of this project follows a particular pattern. The pattern includes all the related factors, from initial data collection plan to data after improvement. The step by step pattern is discussed below.

A. Research

The direction selected to complete this task was to record the information on the quality attributes, build up the control charts, and decide the estimations of the process capability index; all are for the procedures previously presenting any changes. From that point forward, comes about are broke down, talked about with the plant's staff, and enhancements are proposed then put in experimentation. At long last, all estimations are rehashed yet for the procedures after enhancements and adequacy of arrangements is assessed.

B. Sample Size

It is important to decide the number of points taken for the data and even the period from which the data are selected. It is important to gather at least 25 subgroups of information. A couple of quantities of subgroup would not give an adequate measure of the exact calculation of the upper, central and lower control limits, and the higher number of subgroups would delay the presentation of the control charts. The specimen estimate was about 25 tests were selected at every random period over the period of 4 days, in view of the production line information base and from 21st September to 26th September.

C. Analysis of Data

Initially, random data were selected from the distillation plant without any analysis. When a trial was run for random data, the results were not up to the mark. The data were then analyzed, edited, revised and run for second trial. On the next trial, near accurate results were obtained. Hence, these data were finally selected for trail and final run. The data were selected with the aim of generating frequencies with the help of well-studied detailed statistics.

D. Area of Implementation

Berain Factory was established in Riyadh City, Saudi Arabia in 2014. Now, it has integrated water desalination lines and mobilizes of the latest technology. The production of advanced water desalination follows two complementary approaches: reverse osmosis as well as inflatable plastic bottles and packaging. The factory works on water products that are extracted from underground wells, treated and carefully tested for quality with the most modern machinery in the Middle East. It produces healthy water in 330 ml and 600 ml bottles. The average production is 6,000 cartons of the 330 ml water bottles and 7000 cartons of the 600 ml water bottles each day. The total production per year is 2,160,000 cartons of 330 ml water bottles and 2,520,000 cartons of 600 ml water bottles. The total number of employees, presently working in the Berain plant is nearly 150; This includes managers, engineers, technicians and machine operators. Berain is committed to the highest quality and safety standards and has been awarded quality certification from Saudi Organization for Standardization and Metrology SASO. In addition, Berain is meeting international quality standards and specifications and has a number of quality certificates from the public health and safety organization NSF as well as the American Business Women's Association ABWA. Berain's vision is to be a leader in the bottled water industry in Saudi Arabia by providing the highest levels of quality products and customer care.

E. Collecting Data

The raw data were collected from the database of the company. Data were selected from multiple run trials during the process. The raw data were processed and revised to obtain better results. Two types of data were collected viz; i) data before improvement and ii) data after improvement. The two elements of quality selected for the improvement purpose were pH and TDS. Consecutively, for four days the readings were taken, and points were plotted. Improvement on the quality aspect was done and again for next four days reading were taken, for which the points were plotted. The data were divided into three subgroups according to time shifts of each day. Work is done the data collected and the following data are revised. Thus, new data are obtained. X bar & R charts are constructed on the basis the revised data. The revised data are illustrated in Table II.

In Table II which shows that information for estimations of the TDS for the Last Water is before change at production stage. Even for 25 subgroups, three examples are taken at one time in morning, evening, night and midnight as well and average is taken of the water after 3 stages. We can see that the time is the same as in the case of pH since they take cash distinctive sort of value qualities in the meantime and gathering information and bury it to the framework. Likewise, this information is taken arbitrarily from information base in manufacturing plant through period from 20th September to 26th September as well. It is clear in normal of subgroup a considerable measure of stirs is close to target 150 nut it movements to the other side more than other it is not normal for at least seven successive focuses to be above or underneath the center line-3 that is appeared in Fig. 2.

In Table III introduces the estimated pH for the last water from the generation line before given changes. It is important to gather at least 25 subgroups of information, as using only a couple of subgroups would not give an adequate measure of the precise calculation of the focal and control limits, and a larger number of subgroups would defer the presentation as shown in Fig. 3. Three specimens are taken the morning, evening, night and midnight. This information was taken arbitrarily from the information base in the production line from September 20th to September 26th. It is demonstrated that a portion of the data is not in SASO restriction.

From Figs. 2 and 3 it is clearly to observe that at, Total Dissolved Solid (TDS) varieties are also at the principal information obtained from the revised data. It is not much, yet at the same time, the impact of the generation procedure is that the normal is close to the 150 in computation.

TABLE II
MEASUREMENT OF TDS (BEFORE IMPROVEMENT)

S N	Date	Time	X1	X2	X3	Average	Range
1	09/20/17	19:18	147.8504	148.3672	148.048	148.0885	0.5168
2		20:21	150.0088	148.3976	146.984	148.4635	3.0248
3		21:23	147.6984	146.072	146.1632	146.6445	1.6264
4		22:21	146.5584	148.8688	147.4856	147.6376	2.3104
5		23:19	149.112	153.0872	148.7712	150.3235	4.316
6	09/21/17	01:49	147.288	147.1968	147.9416	147.4755	0.7448
7		03:20	150.2064	146.832	149.416	148.8181	3.3744
8		07:23	147.5008	145.9656	147.0296	146.832	1.5352
9		10:25	145.084	150.1912	145.7528	147.0093	5.1072
10		13:25	147.7896	146.832	146.6496	147.0904	1.14
11		16:25	148.2152	148.1544	145.3576	147.2424	2.8576
12		20:44	147.136	148.8992	148.048	148.0277	1.7632
13		23:32	155.8592	150.5344	150.9208	152.4381	5.3248
14	09/25/17	08:45	146.984	148.808	148.8688	148.2203	1.8848
15		09:11	149.4856	151.656	152.7712	151.3043	3.2856
16		12:32	146.756	148.352	145.8288	146.9789	2.5232
17		16:47	146.4824	150.5864	150.7384	149.2691	4.256
18		20:17	146.3608	149.264	147.592	147.7389	2.9032
19		23:50	147.4096	147.06	148.2	147.5565	1.14
20	09/26/17	03:52	147.592	146.6224	148.2608	147.4917	1.6384
21		05:18	147.8504	148.3672	148.048	148.0885	0.5168
22		08:25	150.0088	148.3976	146.984	148.4635	3.0248
23		10:47	147.6984	146.072	146.1632	146.6445	1.6264
24		13:27	146.5584	148.8688	147.4856	147.6376	2.3104
25		16:42	149.112	153.0872	148.7712	150.3235	4.316

TABLE III
MEASUREMENT OF pH (BEFORE IMPROVEMENT)

S N	Date	Time	X1	X2	X3	Average	Range
1	09/20/17	6.32	6.33	6.60	7.38	6.77	1.05
2		6.39	6.34	6.76	7.47	6.86	1.14
3		6.42	6.93	6.90	6.97	6.93	0.07
4		6.45	6.99	6.74	7.35	7.03	0.61
5		6.43	6.38	6.72	7.37	6.82	1.00
6	09/21/17	6.35	6.21	7.10	7.73	7.01	1.52
7		6.51	6.80	6.46	7.27	6.84	0.81
8		6.46	6.17	6.79	7.78	6.91	1.61
9		6.29	6.59	6.38	7.00	6.66	0.62
10		6.48	6.89	7.11	7.54	7.18	0.66
11		6.48	6.35	6.71	7.46	6.84	1.10
12		5.89	6.59	6.38	7.55	6.84	1.17
13		6.19	7.00	7.16	7.46	7.20	0.46
14	09/25/17	6.29	6.02	6.94	6.91	6.63	0.92
15		6.28	6.19	7.17	7.40	6.92	1.20
16		6.34	6.27	6.84	7.70	6.94	1.43
17		6.29	6.28	6.67	7.34	6.76	1.06
18		6.3	6.51	6.79	7.03	6.78	0.52
19		6.39	6.66	7.06	7.38	7.04	0.72
20	09/26/17	6.4	6.78	6.99	7.44	7.07	0.66
21		6.26	6.34	6.77	7.69	6.93	1.35
22		6.33	6.92	6.69	7.02	6.88	0.33
23		6.47	6.91	7.03	7.72	7.22	0.81
24		6.46	6.66	6.71	7.49	6.95	0.83
25		6.08	6.22	6.96	7.21	6.80	0.99

International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:12, No:3, 2018

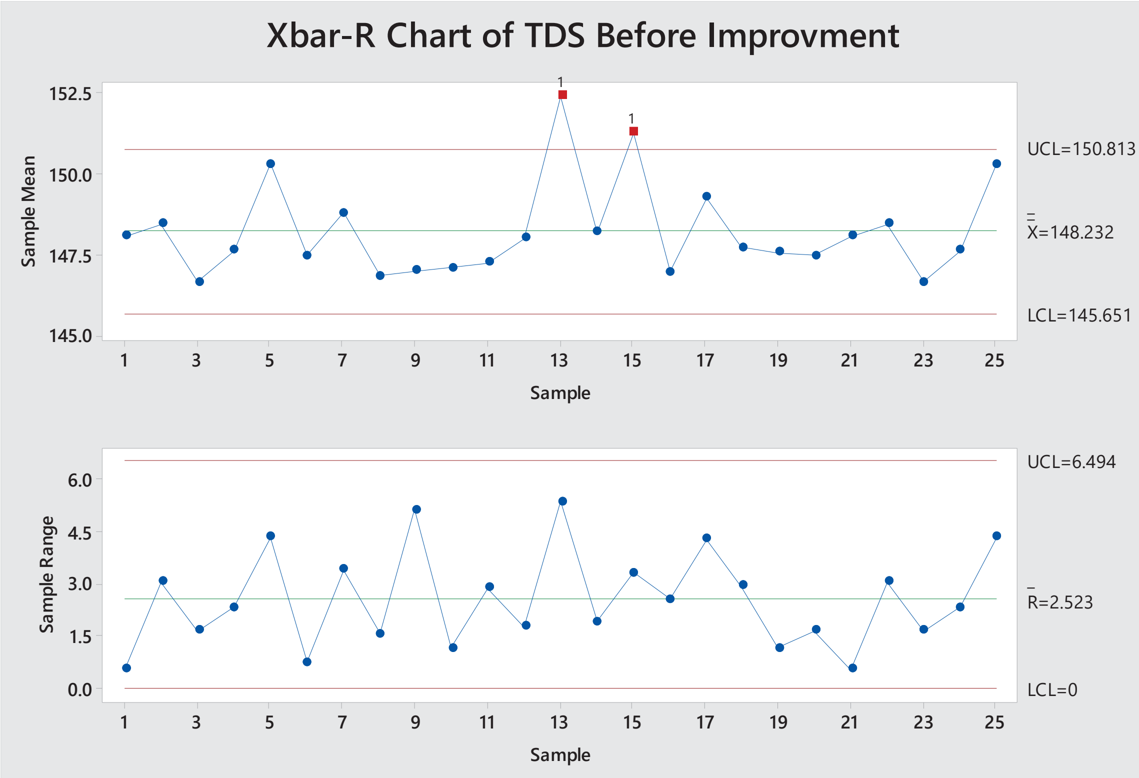

Fig. 2 Xbar & R charts of TDS (Before Improvement)

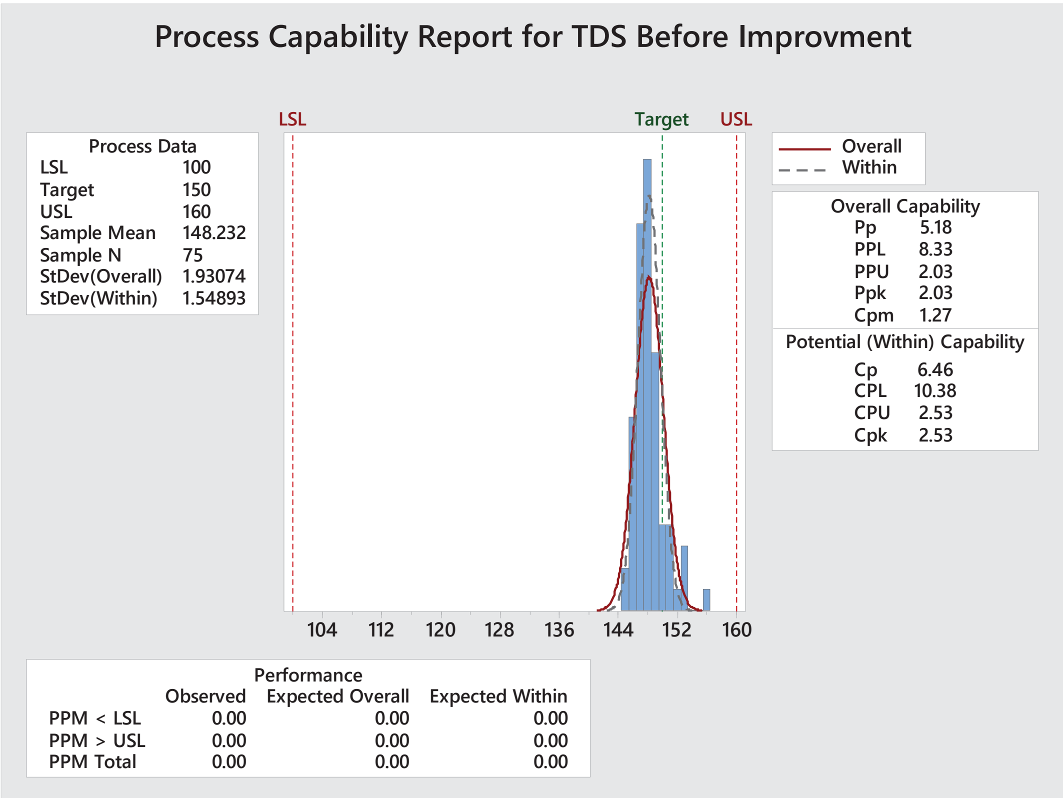

Fig. 3 Process Capability of TDS (Before Improvement)

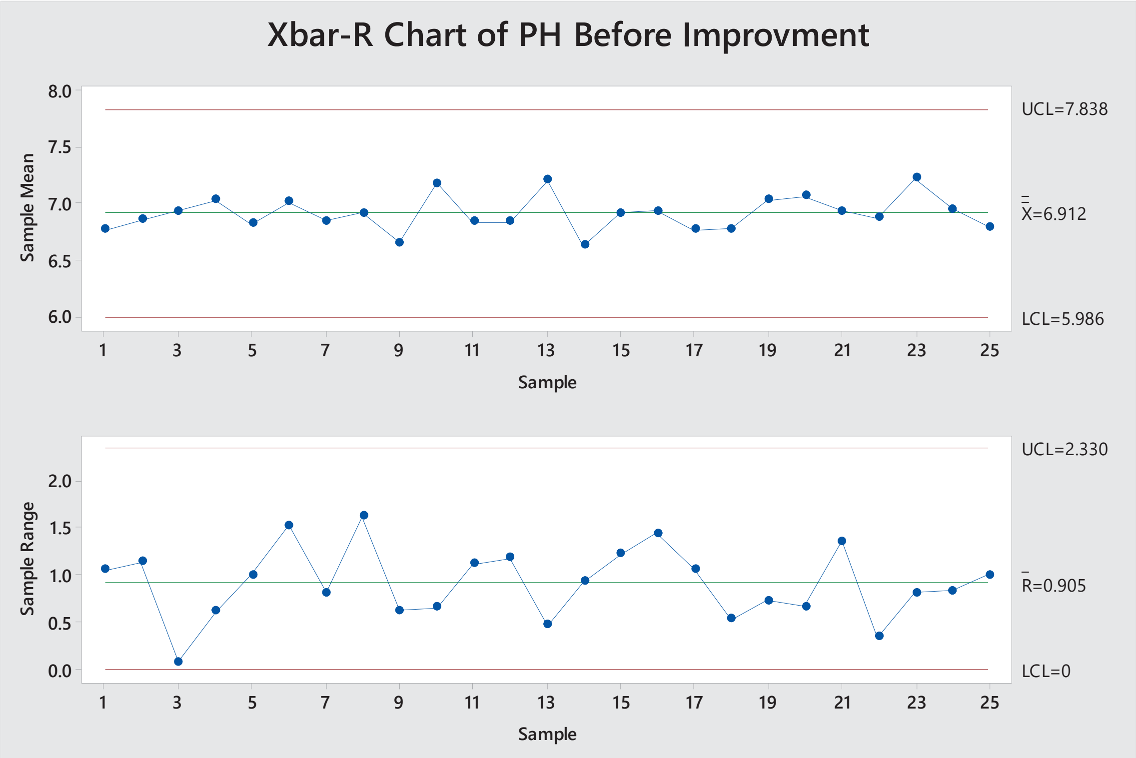

Fig. 4 Xbar- R Chart of pH (Before Improvement)

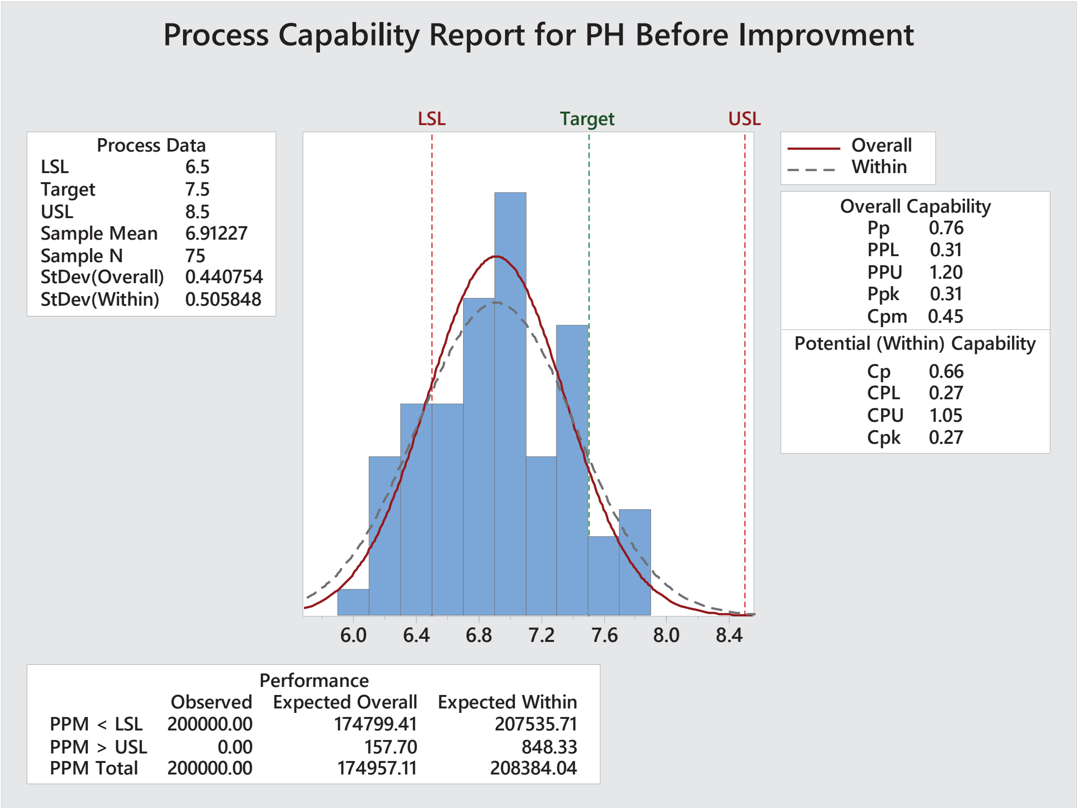

Fig. 5 Process Capability of pH (Before Improvement)

Notwithstanding, there are a few points forced outside of control limits (point 13 & 15); therefore, there is an issue in the process, shows up in R chart. In Fig. 3, the dispersions are moved to bring down line. The further discussion about the graphs and charts will be seen in the improvement stage.

Fig. 4 varieties in the process more, and in R diagram shows that at points 3,8 and 22 which are reflected directly, can conclude that the current process is not steady or under control. The deflections or variations in the graph make sense if this information was taken at a time like the evening or morning; likewise, incorrect information was buried in the framework. In Fig. 5, process capacity which is more obviously indicated for dispersion of the pH information can show that an issue is underway, in light of the fact that the circulation was moved outside of the constraint. Further discussion about the graphs and charts will be seen in the improvement stage.

V. Improvement Stage

As the plant was facing the issue of quality, a corrective plan of action was much needed to overcome the problem. So, after the initial stage of collecting the data and finding loopholes in the system, a generation of improvement plan is put into action. The collected data and the results were discussed with plant employees. They came with a conclusion that the quality of the drinking water was reaching its assured levels. Thus, the focus of the plant was to improve quality of product and bring it under control limits.

After a constant observation on the process, a human error was detected in the system. The problem was the staff assigned for the supervision of quality checks were not able to concentrate after a certain period of time which directly hampered the quality of water. The duration of each shift was too long for every personal and that become the bottleneck of the whole system. As an improvement, each shift was divided into 2 parts. Hence, the efficiency of the person working remains constant throughout and improvement in the quality levels is also observed. The results of the data after the improvement stage is discussed in the further stage.

VI. Observations

Freedom of perceptions suggests that the present information esteem gives no sign of the following information esteem. For autonomous procedures in a condition of actual control, the best indicator of the following perception is the normal. For subordinate (or auto correlated) forms, the best indicator of the following perception depends on some capacity of the present perception (or an earlier perception) [4]. For instance, the open-air temperature at a particular time is probably going to be exceptionally connected with the temperature after some time, clarifying to some extent why the TV meteorologist can precisely foresee that it is in truth hot outside, and will stay hot for the majority of the day. Comparable perception was directed on the model to be improved [5], [6].

Consider how X-bar graphs are developed. Every subgroup is utilized to appraise the "here and now" normal and variety of the procedure. The normal here and now variety (R-bar) is then used to appraise as far as possible on both the X-bar and Range graphs. In the event that the procedure is "in charge", or steady, at that point the normal here and now variety gives a decent sign of long haul variety. Accordingly, in shaping subgroups, a helpful decide to recollect is that the here and now (or inside subgroup) variety must be similar to the long haul (or between subgroup) variety. In pragmatic terms, the potential reasons for inside subgroup variety ought to be equivalent to those causes that exist between subgroups. So also, the Individual-X/Moving Reach graph is likewise inclined to these mistakes. Here, since the subgroup measure is one, the variety between successive subgroups is utilized to figure the short-term variation.

After the suggested improvement was implemented on the system, data was again collected and revised to see whether the improvement solution was beneficial for the plant or not. Results was calculated in the same manner as previously presented. Analysis was done on the improved data and final verdict on the improvement was given. The quality elements which were targeted for the improvement, i.e. TDS and pH were noted down at every equal interval of time at all stages [7], [8]. Average was taken for the data of each stage and later on divided into 3 subgroups according to that particular stage.

The data was collected for consecutive four days i.e. from 11/02/2017 to 11/08/2017. Xbar & R charts were constructed on the basis of data collected and later on process capability was calculated. The improved data and its analysis is shown below.

Table IV shows the Measurements of the TDS for the final water after improvement. All data are observed close to the target value (150). Hence, we can say that, improvement has been done on the process. We have imposed calculated data on the graphs, so it becomes easier to notice the required improvement. The improvement is illustrated in Figs. 6 and 7.

Table V shows that the values of pH of the Final Product which is after Improvement process. It has 25 subgroups which is taken at an equal interval of time. The improvement in system process the corrective action was happen lately before taking these data from the line. After the calculations, it can be observed that average is set within the control limits.

At TDS we got a decent and fulfillment results as seen in the Fig. 7. The following results are obtained because all the points ate within control limits, i.e. between Upper Control Limit (UCL) and Lower Control Limit (LCL), as shown in the Fig. 6. The fact of the matter that the variations are close to the target value, it can be said that the improvement is done within the selected process, which is ponder changes generation forms. The graphs are enough to prove the change within the process to new improvement level, by exchange at the outcomes.

From Fig. 8 we can conclude that, the improvements in production are observed and process is stabilized, with less variations through the period of processing. In addition, if we closely observe in Fig. 9, it can be seen that the target is moved or placed close to target which is at level 7.5 ph. The

International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:12, No:3, 2018

reflected improvements with good evidence with different distribution to the better way [9].

TABLE IV
MEASUREMENTS OF THE TDS FOR THE FINAL WATER (AFTER IMPROVEMENT)

S N	Date	Time	X1	X2	X3	Averages	Ranges
1	11/02/17	19:18	150.3965	150.412	151.2955	150.7013	0.899
2		20:21	149.6525	147.9475	151.3265	149.6422	3.379
3		21:23	149.3735	150.7065	148.955	149.6783	1.7515
4		22:21	149.2495	149.885	151.807	150.3138	2.5575
5		23:19	149.854	149.73	148.9705	149.5182	0.8835
6	11/03/17	03:49	150.505	151.0785	150.257	150.6135	0.8215
7		05:20	152.21	151.3265	150.35	151.2955	1.86
8		07:23	151.9	149.668	150.536	150.7013	2.232
9		10:25	151.094	150.8615	152.768	151.5745	1.9065
10		13:25	150.505	152.365	149.513	150.7943	2.852
11		18:25	151.125	149.9315	148.8155	149.9573	2.3095
12		20:44	151.187	148.6295	149.885	149.9005	2.5575
13		23:32	150.97	149.544	151.218	150.5773	1.674
14	11/07/17	01:45	148.8465	148.8465	152.5355	150.0762	3.689
15		04:11	153.1555	151.838	150.66	151.8845	2.4955
16		07:32	149.73	151.466	148.738	149.978	2.728
17		10:47	151.0785	150.0865	153.5585	151.5745	3.472
18		13:17	148.18	151.59	152.21	150.66	4.03
19		16:50	152.83	150.195	149.9625	150.9958	2.8675
20	11/08/17	19:52	149.451	153.171	150.536	151.0527	3.72
21		22:18	150.3965	150.412	151.2955	150.7013	0.899
22		06:33	149.6525	147.9475	151.3265	149.6422	3.379
23		07:47	149.3735	150.7065	148.955	149.6783	1.7515
24		09:27	149.2495	149.885	151.807	150.3138	2.5575
25		11:42	149.854	149.73	148.9705	149.5182	0.8835

TABLE V
THE VALUES OF PH OF THE FINAL PRODUCT (AFTER IMPROVEMENT)

S N	Date	Time	X1	X2	X3	Averages	Ranges
1	11/02/17	19:18	150.3965	150.412	151.2955	150.7013	0.899
2		20:21	149.6525	147.9475	151.3265	149.6422	3.379
3		21:23	149.3735	150.7065	148.955	149.6783	1.7515
4		22:21	149.2495	149.885	151.807	150.3138	2.5575
5		23:19	149.854	149.73	148.9705	149.5182	0.8835
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10		13:25	150.505	152.365	149.513	150.7943	2.852
11		18:25	151.125	149.9315	148.8155	149.9573	2.3095
12		20:44	151.187	148.6295	149.885	149.9005	2.5575
13		23:32	150.97	149.544	151.218	150.5773	1.674
14	11/07/17	01:45	148.8465	148.8465	152.5355	150.0762	3.689
15		04:11	153.1555	151.838	150.66	151.8845	2.4955
16		07:32	149.73	151.466	148.738	149.978	2.728
17		10:47	151.0785	150.0865	153.5585	151.5745	3.472
18		13:17	148.18	151.59	152.21	150.66	4.03
19		16:50	152.83	150.195	149.9625	150.9958	2.8675
20	11/08/17	19:52	149.451	153.171	150.536	151.0527	3.72
21		22:18	150.3965	150.412	151.2955	150.7013	0.899
22		06:33	149.6525	147.9475	151.3265	149.6422	3.379
23		07:47	149.3735	150.7065	148.955	149.6783	1.7515
24		09:27	149.2495	149.885	151.807	150.3138	2.5575
25		11:42	149.854	149.73	148.9705	149.5182	0.8835

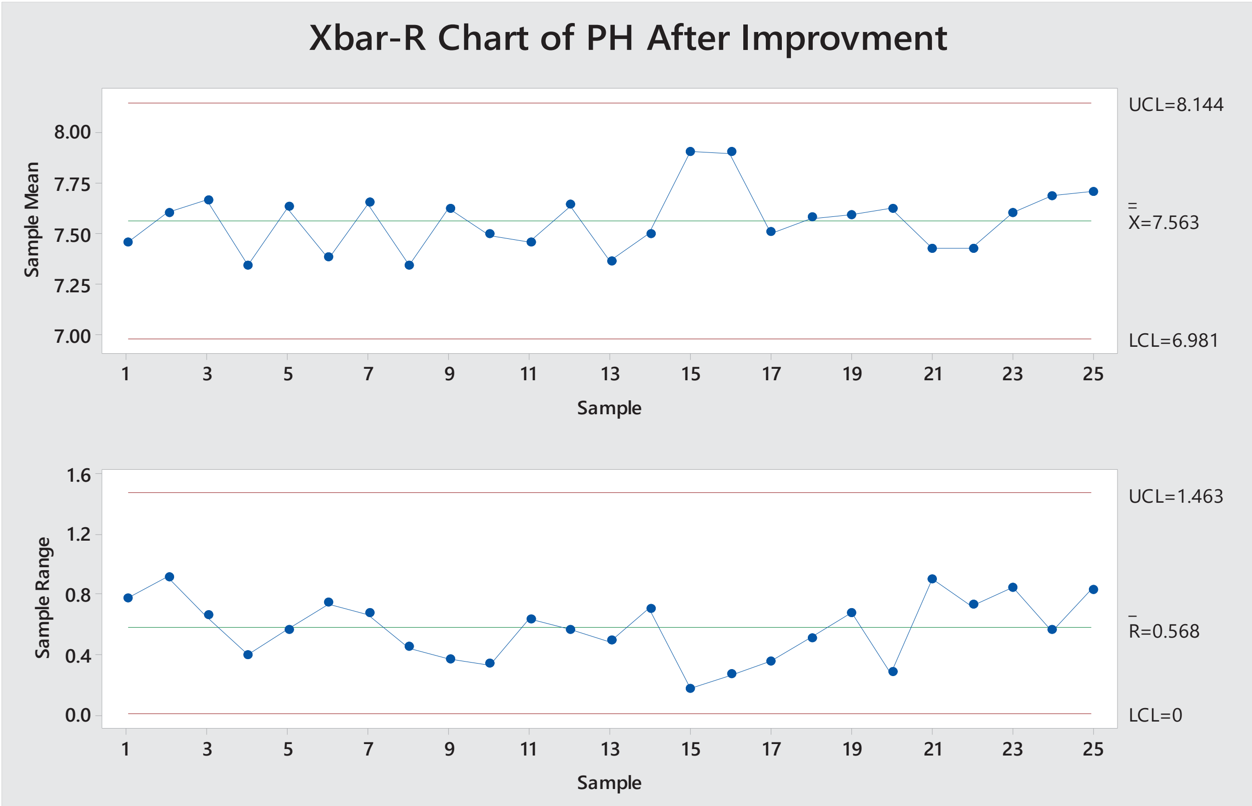

Fig. 6 Xbar & R Chart of pH (After Improvement)

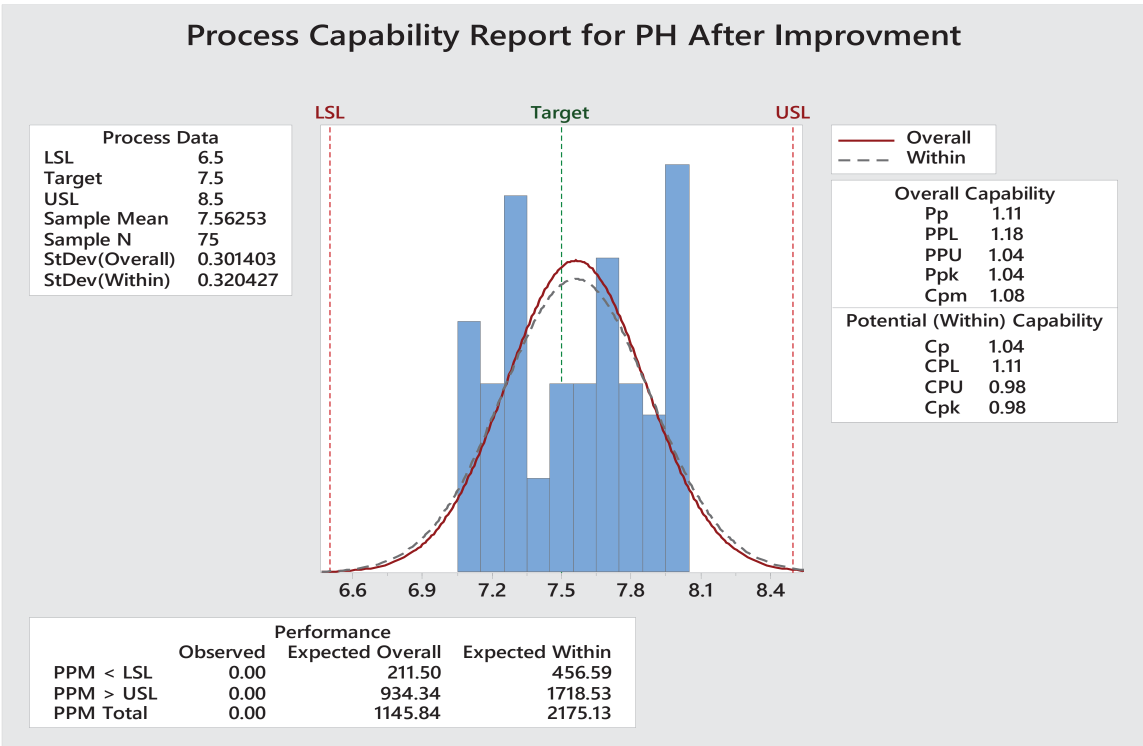

Fig. 7 Process Capability of pH (After Improvement)

TABLE VI
PARAMETERS OF THE TDS OF THE FINAL PRODUCT BEFORE AND AFTER IMPROVEMENT

Parameters	Period of Measurement w.r.t. the SPC-System Development	
	Before	After
UCL_X	150.813	152.834
X Double Bar	148.232	150.454
LCL_X	145.651	148.074
C_P	6.46	7.56
C_{PK}	2.53	2.41
UCL_R	6.494	5.988
R Bar	2.523	2.326

TABLE VII
PARAMETERS OF THE PH OF THE FINAL PRODUCT BEFORE AND AFTER IMPROVEMENT

Parameters	Period of Measurement w.r.t. the SPC-System Development	
	Before	After
UCL_X	7.838	8.144
X Bar	6.912	7.563
LCL_X	5.986	6.981
CP	0.66	1.04
C_{PK}	0.27	0.98
UCL_R	2.330	1.463
R Bar	0.905	0.568

VII. RESULTS AND DISCUSSION

The final results of TDS and pH value are illustrated in Table VI. The difference in the values, before and after improvement process are shown. The values are obtained from revised charts and graphs and hence the percentage improvement can be obtained.

From Tables VI and VII, we can say that;

I. The variations in the targeted quality aspects has been decreased to a considerable level. It can be clarified by comparing the control points in the Xbar and R charts. When the data was taken before improvement process, few control points were dispersed out of control limits. This means, the process is not stable and is not able to match the quality index. But, seeing the results after the improvement technique is applied, the control points are under UCL and LCL, hence the process is now stable.

II. The process capability depends on the control charts which are presented before. The process capability in the form of histogram, defines the given process is accepted or not. Looking at the results from above table, and comparing the before and after improvement data, it can be concluded that improvement has imposed on the process. The values of Cp and Cpk are obtained to give verdict on the amount of improvement done.

III. As a result, the indices of the process capability have increased to an optimum level. The control points in Xbar & R charts of pH and TDS now lies close to central value of 7.5 and 150 respectively. Thus, it is proved, that applying SPC techniques have had been beneficial on the selected process of the company.

VIII. CONCLUSION

The fact that actualizing the SPC framework and as per the outcomes acquired and just talked about here above, it is reasoned that the created SPC framework has demonstrated adequacy in lessening the fluctuation in the quality attributes through finished the generation procedure.

Also, the SPC technique has demonstrated high adequacy in focusing the procedures (making the mean of the estimations of the quality attributes so near their objective esteems).

Because of the procedure ability lists have been fundamentally expanded. Likewise, the expansion in the process capacity list i.e. CPK, specifically, was behind the abatement in the percent nonconforming water packages. What's more is the general examinations of the control outlines, by the plant, were behind initiating the support activities, expanding the recurrence of water treatment, and receiving new measurements of optimizing whole system.

The conviction of achieving the goal that "being inside the control limits" has been changed to "process in control" [10]. Mindfulness with quality ideas and significance, inside the plant, is broadly expanding each day.

REFERENCES

[1] Ajit Singh "Implementation of ISO 9000:2008, Quality Management Systems", 2008.
[2] Charles A. Cianfrani, Joseph J. Tsiakals, and John E. (Jack) West "ISO9001:2008 Explained", Third Edition, 2008.
[3] Dale H. Besterfield "Quality Control", Eight Edition, Pearson Education, 2009.
[4] David Hoyle "ISO 9000 Quality Systems Handbook", Fourth Edition, 2014.
[5] Denise E, Robitaille "ISO 9001:2008 for Small and Medium- Sized Businesses", Second Edition. "Power system harmonics: An overview", IEEE Trans. Power App. Syst., vol. PAS-102, pp. 24552460, 1983
[6] Heizer J, Render B. Operation Management. 9th Edition. New Jersey 2008. Pearson Education.
[7] Oakland J S. Oakland on Quality Management. United Kingdom. Butterworth Heinemann, 2000.
[8] T. C. Shuter, H. T. Vollkommer Jr., and J. L. Kirkpatrick, "Survey of harmonic levels on the American electric power distribution system", IEEE Trans. Power Delivery, vol. 4, pp. 22042213, 1989
[9] M R Mc Granaghan, D.R. Moeller and M.J Samotyj, "Voltage sags in industrial systems", IEEE Transactions on industry applications, Vol 29. no.2. Pp.397-402 April 1993
[10] James R. Evans and William M. Lindsay, Managing for Quality and Performance Excellence, 2012. Donna C. S. Summers, Quality, 5th ed., Prentice-Hall, 2010.