ELECTRONIC WASTEWATER MANAGEMENT USING STATISTICAL PROCESS CONTROL

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ARSTRACT

This paper will present few results based on the implementation of statistical process control (SPC) in an effluent treatment plant. A fundamental tool of SPC i.e. Control Charts are plotted for several variables such as pH, BOD and suspended solids level versus time. From these control charts, the true capability of the operating process can be predicted and established Furthermore, several trends found from the charts could serve as indicators for process stability and the extent of deterioration. From the results, it was found out that most of the monitored variables were under statistical process control since most of the charts showed that the random distribution over time was repeatable and predictable (normal distribution). Only in one of the charts i.e. the control chart for the concentration of a contaminating material, shows that about 20% of the samples taken were outside the upper control limit (UCL). This phenomena was a result of the excessive dumping of the contaminating materials to the treatment plant on that particular days. In conclusion, the process could be improved by using SPC technique that lead to saving operating cost. The installation of an on-line SPC alarms is suggested so that early warning could be given for any disturbance to the treatment plant.

KEYWORDS

Statistical process control; electronic waste effluent treatment; control charts; pollution; process monitoring and control.

1. INTRODUCTION

Statistical process control (SPC) has won a widespread recognition for its effectiveness procedure in problem solving. The main reason why it is so effective is simply because it can monitor and analyse the behaviour of the process. Consequently, by doing this, it can improve the quality of products and limit waste. SPC methods are applied to actual plant performance compared to process models which are typically theoretical operation. Other than monitoring, it also can be utilised to detect equipment and instrument malfunctions, gradual deterioration and falling out of adjustment in equipment performance, and operator slackness. SPC is not only boosting product quality and variability, its also can increase the plant productivity, cutting energy consumption, reducing inventory levels, and improving maintenance [1].

2. TOOLS FOR STATISTICAL PROCESS CONTROL (SPC)

There are several effective tools used in SPC. The most important tool is the control chart because it can give a powerful impression, instantaneous, intuitive grasp of the situation portrayed. The horizontal axis shows time and date; the vertical axis gives data on quality, such as rate of defects due to wear in equipment or inefficient of mixing. Any divergence from the norm can be easily detected by seeing the changes charted. The interpretation of SPC is always based on data or facts; thus, the user should come out with the logical cause when an "out of control" situation occured. This happened mainly because of two reasons [2]:

(a) fluctuations, upsets and breakdowns that result from the process not operating as designed, e.g., acid spills, power failure and pump break down.

(b) stable inherent variability resulting from the process operating as designed, e.g., analytical measurement techniques and chemical treatment.

3. SPC APPLICATION IN A ELECTRONIC WASTEWATER TREATMENT PLANT (EWTP)

The subject of this study is located at the end of silicon valley where the hydraulic retention time of the inlet to the outlet of the EWTP is about 13.5 hours. Novel quality approach is concentrated on inspection of finished goods. In contrast to the traditional approach of quality control, SPC involves the integration of quality control in each step of production process until the wastewater treatment. Standard such as Control Limit (CL) is established for each step and an acceptable range within Upper Control Limit (UCL) and Lower Control Limit (LCL) about each standard is determined. As long as the procedure for each step yields a product within its set range, quality is ensured [3]. When the acceptable range is exceeded, or a trend which indicates the range will soon be exceeded is identified, the step is to stop the process and adjust the system to bring it back in line with standard or around Control Limit (CL). It should be mentioned that statistical methods also help prevent over adjustment by indicating when the process should be left alone. In this manner, quality is ensured at each step in the process and rejects are not passed along for further processing. While traditional quality control efforts emphasize the detection of poor quality in end items, SPC stresses the prevention of poor quality throughout the process. Traditional quality control efforts can be reduced and in some cases eliminated with a well designed SPC program.

Implemention of SPC program in a company requires planning, time, effort and money. The difference between SPC from other new, yet routine company programs is the level of management involvement required. Upper level management must become and stay actively involved in the SPC program to ensure its success [4]. The management information provided by the SPC system will enhance management ability to make smart policy decisions. Increased productivity through reduced waste and improved quality are both short and long term benefits of statistical process control.

4. DESCRIPTION OF THE EWTP PROCESS

The schematic block diagram of the waste effluent treatment plant is shown in Figure 1. The tanks which were subjected for quality control were waste acid sump, balancing tank, mixing tanks 1, 2, 3 and 4, and settling tanks 1 and 2. Wastewater enter the acid sump tank mainly from four sources: solder tip, tin plating, wafer sawing process and deionized water plant. It mainly contains dye, acids and other organic materials. The function of having the balance tank is to maintain the level of the wastewater in the treatment plant. From the balancing tank the wastewater is transfered to mixing tank 1. Here, the wastewater pH is monitored by a pH controller where a sodium hydroxide solution will treat the system when the pH is low.

In mixing tank 2, polyelecroytes solution is added to the waste water. As the water flow to settling tank 1,most of the fine flocs or heavy metal particles have settled. The wastewater then flow to mixing tank 3 where the pH is again being monitored to ensure it will be in the range of 5.5 to 8.0. Mixing tank 4 will further control the pH variation and provide better mixing. Finally, the treated water will be discharged to the river.

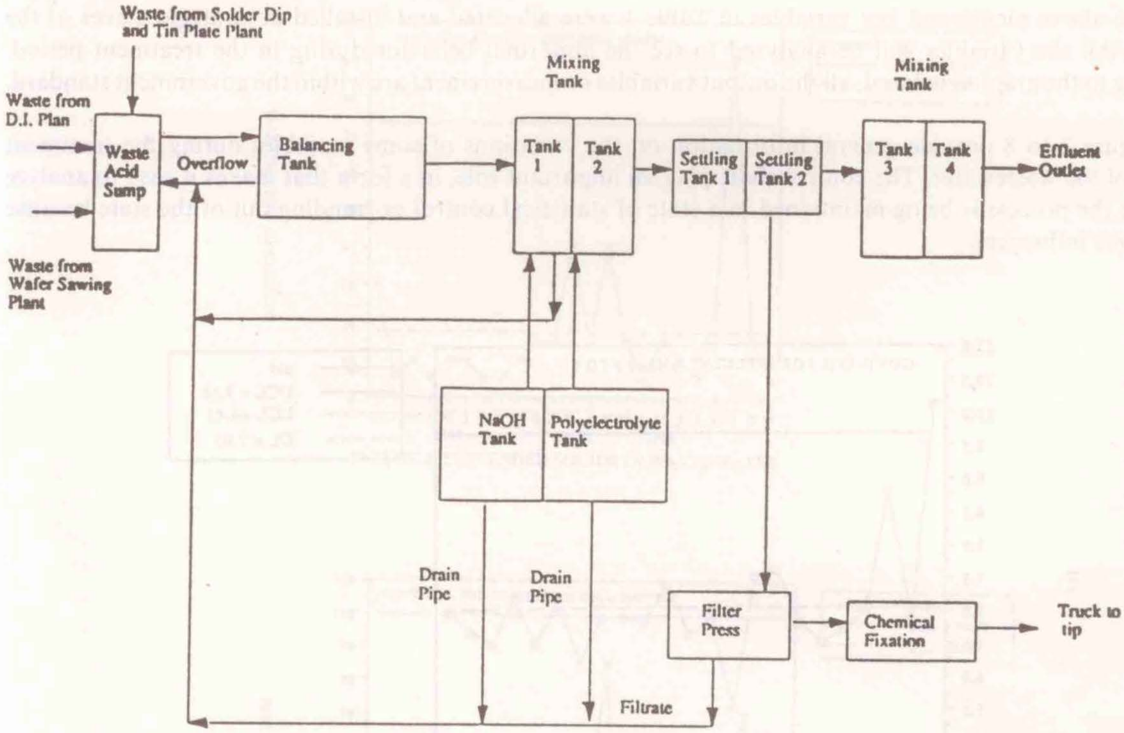

FIGURE 1: SCHEMATIC BLOCK DIAGRAM OF WASTE EFFLUENT TREATMENT PLANT.

5. KEY VARIABLES FOR THE PROCESS

The first step is to prioritize those variables which should be addressed. Table 1 show the key variables chart for the process. It shows the input variables (disturbance) in the process, the intermediate variables which consist of the controlling mechanism, buffer and output variables as measurement.

Table 1 Key variables for the process.

KEY PROCESS (INPUT) OPERATING VARIABLES	INTERMEDIATE VARIABLES	KEY OUTPUT OPERATING VARIABLES
Inconsistent discharge	Conrol hardware	pH
Pump shutdown	Treatment vessels	BOD
High upstream production	Instruments perform calibration	COD
Cleanup shutdown	Instruments perform calibration	SS
Pipeline blinding or clogging	Manual data collection	Lead content
House keeping	Type of coagulants and flocculants	Iron content
Pipeline blinding or clogging	Laboratory analysis	Nickel content

The above mentioned key variables in Table 1 were allocated and installed in strategic places of the EWTP. All the variables will be analyzed to see the abnormal behavior during in the treatment period. Refering to the graphs enclosed, all the output variables or measurement are within the government standard.

Figure 2 to 8 provide general information on the variations of some variables during the treatment period of the wastewater. The control chart play an important role, in a form that makes it easy to analyze whether the process is being maintained in a state of statistical control or trending out of the state because of adverse influences.

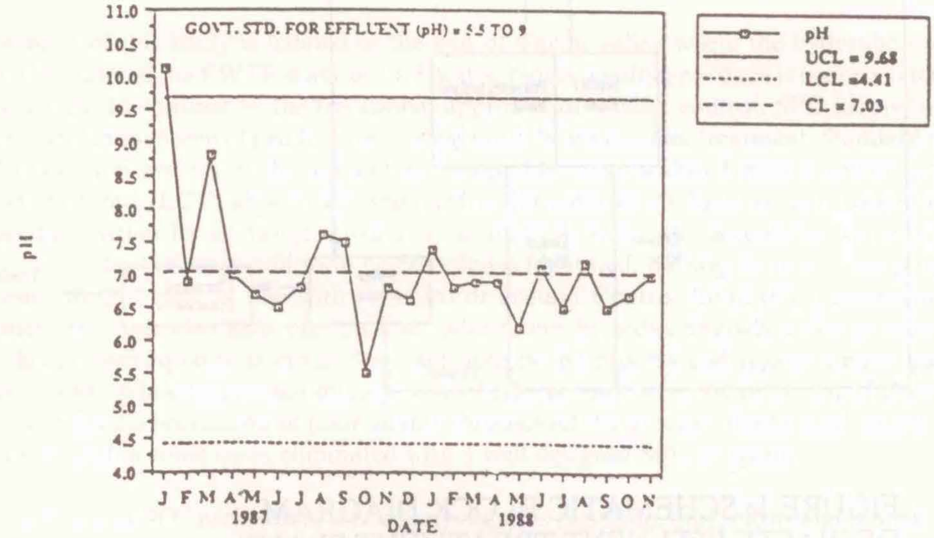

FIGURE 2: pH LEVEL IN WASTEWATER

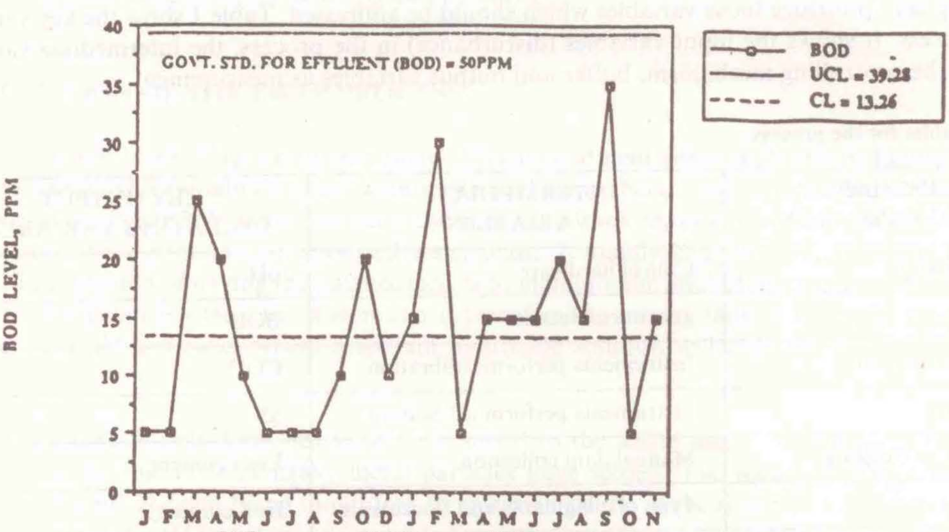

FIGURE 3: BOD LEVEL IN WASTEWATER

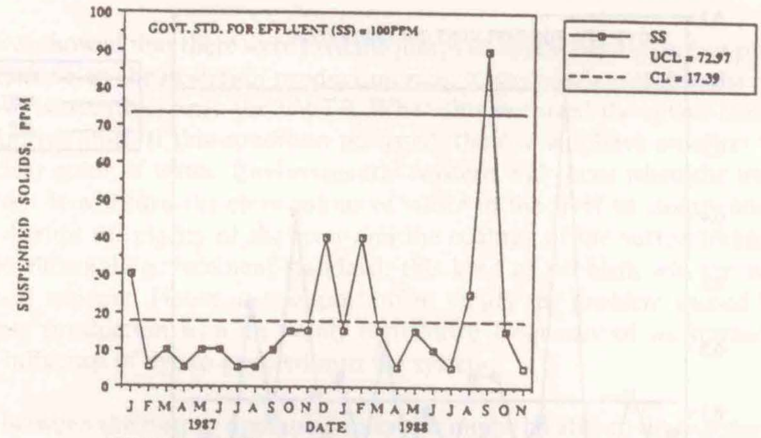

FIGURE 4: SUSPENDED SOLIDS IN WASTEWATER

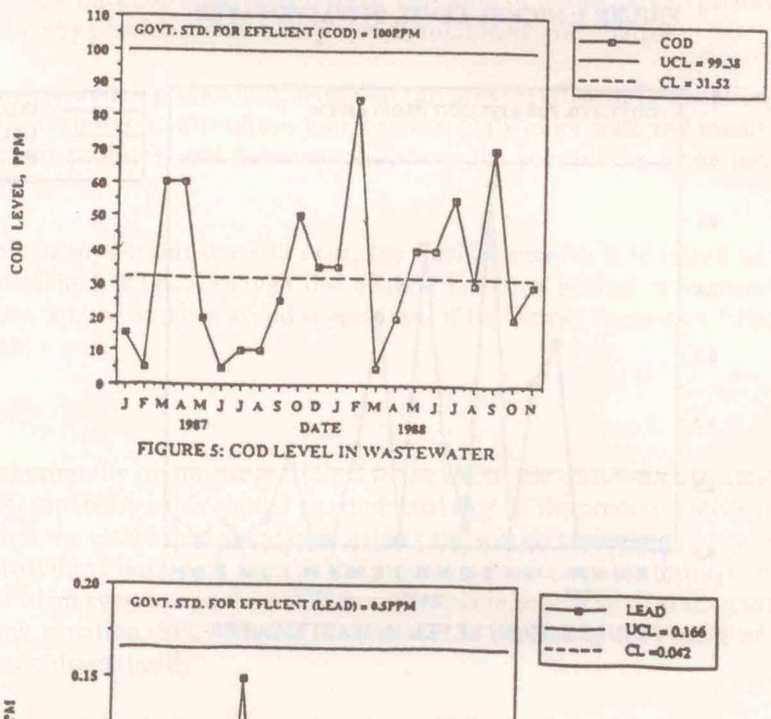

FIGURE 5: COD LEVEL IN WASTEWATER

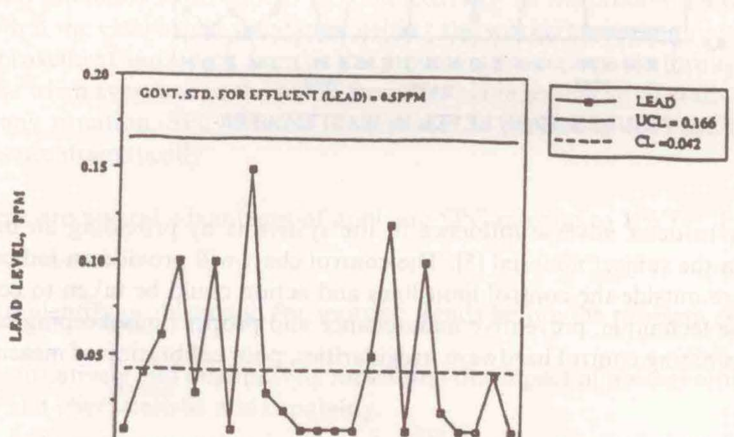

FIGURE 6: LEAD LEVEL IN WASTEWATER

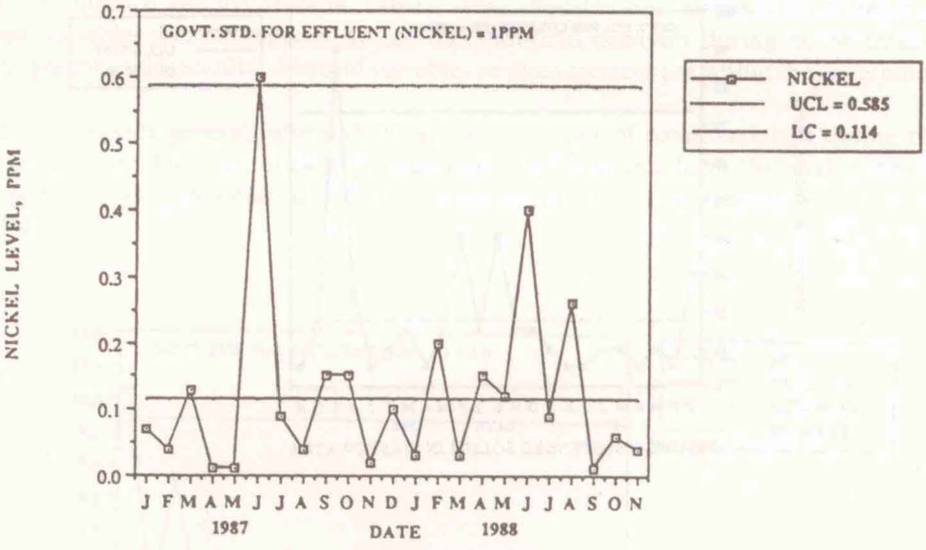

FIGURE 7: NICKEL LEVEL IN WASTEWATER

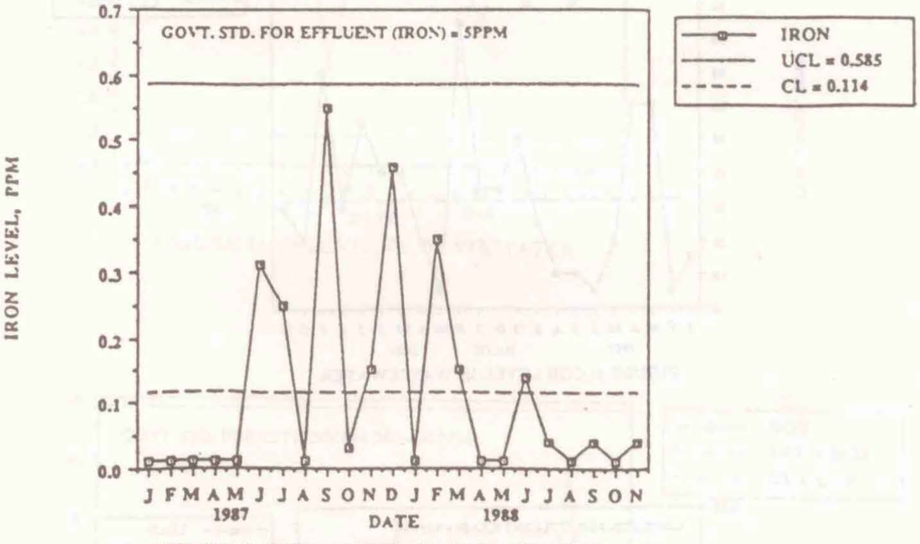

FIGURE 8: IRON LEVEL IN WASTEWATER

The best way to deter adverse influence in the system is by providing an on-line statistical process control analysis on the subject material [5]. The control chart will provide an indication of abnormal trend when the points are outside the control limit lines and action could be taken to comprehend the problem. By utilizing on-line technique, preventive maintenance and proper housekeeping can be done according to schedule, thus eliminating control hardware irregularities, poor calibration of measurement instruments and vessels fouling[6].

Vessel cleanup shutdowns were scheduled at least once every eight month to make sure that there is no deposit in the tank. This procedure is essential to prolong the life span of the tank due to the corrosive material that enter the EWTP.

6. DISCUSSION

Some of the figures showed that there were extreme jumps or spikes during certain period of production. When assessment was done on the upstream production rate, it was confirmed that the operators discharge inconsistent amount of waste (dye) onto the EWTP. When this occurred the spikes from the control chart jump out from the control limit. If this condition persisted, the dye will have an effect to the EWTP. The dye will change the clear color of water. Environmental concern will occur when the treated wastewater is discharge into the river. It will tùrn the clear colour of water in the river to cloudy and finally to purple, and would certainly disrupt the clarity of the river and the ecology of the surroundings. Although all the parameters are in the allowable government standard, this kind of problem will tarnish the name of the company with the local resident. Hence, it is important to rectify the problem caused by this irregularity unloading by upstream production with an evenly distributed frequency of wastewater discharge before allowing the adverse influence of dye to proceed into the system.

The correlation between the output operating variables might be able to draw some light into the dye-removing mystery, e.g. the possibility of pH of wastewater as the potential cause of failure in coagulation and flocculating. By charting pH against clarity of wastewater, it is possible to detect whether there is a cause and effect relationship between the two. This can then be followed by an installation of an on-line control for analysis or flow injection analysis (FIA) [2]. This kind of technique can perform on-line analysis instantaneously and thereby provide continuous process monitoring and control.

There is a need to determine a proper flocculant that can provide efficient flocculation in the wastewater as the characteristic of wastewater varies from time to time. Only more tests and monitoring can provide better correlation for this problem, and hence narrow down the possibilities of unspecified disturbances for the actual use of FIA.

If the problem of the mysterious dye still exist, the final alternative is to install an activated carbon filter at the final part of the EWTP. Although this method has been proven to be successful, it would be an expensive alternative. So, the authors would suggest that if the former suggestion failed then one should use the later suggestion.

7. CONCLUSION

This paper looked primarily on the usage of SPC in the electronic wastewater treatment. Before implementing SPC, a process capability study should be conducted first. If the process is incapable of consistendy producing output within the established standards, neither the workers nor the process can be expected to show the quality improvement until such time as the process is made capable through management intervention. It only works when everyone in the plant, from the management to operators are really serious in implementing it. In any situation, SPC method is successful in predicting the cause of the problem and improve the performance dramatically.

In summary, there are several advantages of applying SPC method to EWTP. Two of the advantages are:

(a) the ability to identify problem and for spotting trends before the problem occured.

(b) a way to quantitatively and qualitatively measuring the impact of process modifications on process parameters and characteristic and capability.

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