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Applying process analytical technology framework to optimize performance of wastewater treatment process

Key words: Fuzzy goal optimization, Multiple responses, Wastewater, PAT

The process analytical technology (PAT) framework is a combination of tools that, when used within a system, can provide useful means for acquiring information resulting in continual process improvement, such as multivariate techniques, data acquisition and analysis, process analysis methods, process control tools, and continual improvement and a knowledge management approach. A summary of the tools that are commonly utilized in the PAT framework is displayed in Fig. 1.

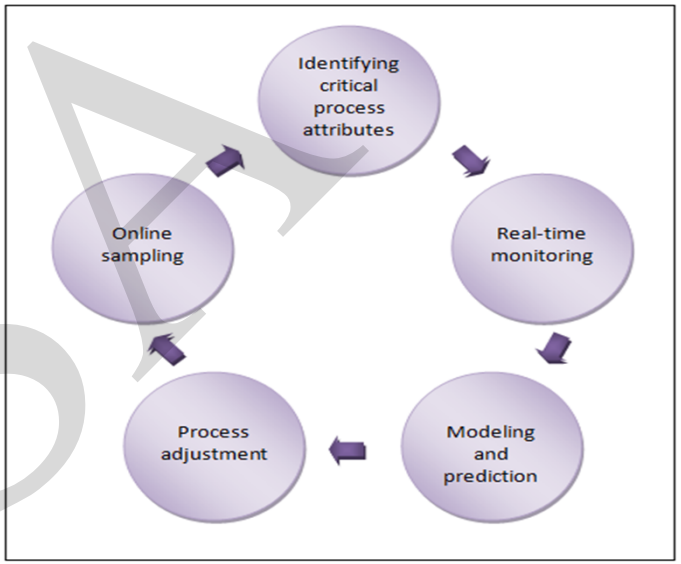

Fig. 1. The PAT framework.

Improving the performance of the waste water treatment process has received significant research attention. The treatment process for wastewater is mapped as shown in Fig. 2.

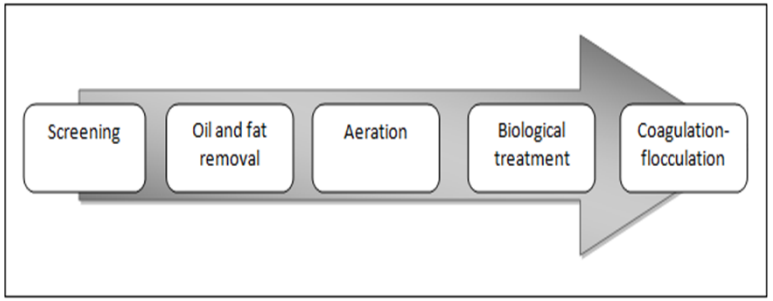

Fig. 2. Process mapping of treatment process.

The turbidity is measured using a portable DR/890 colorimeter instrument, while the SVI is measured manually using the standard method. The MA-MR control charts for turbidity and SVI are constructed and depicted in Figs. 3 and 4, respectively.

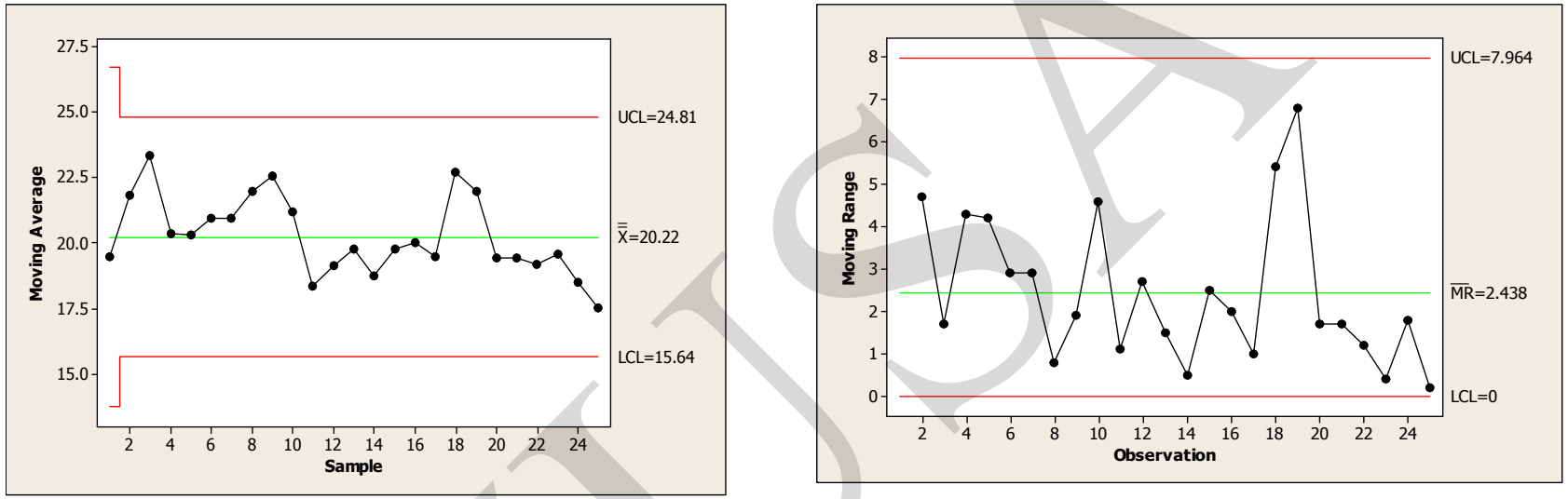

Fig. 3. MA-MR control charts for turbidity .

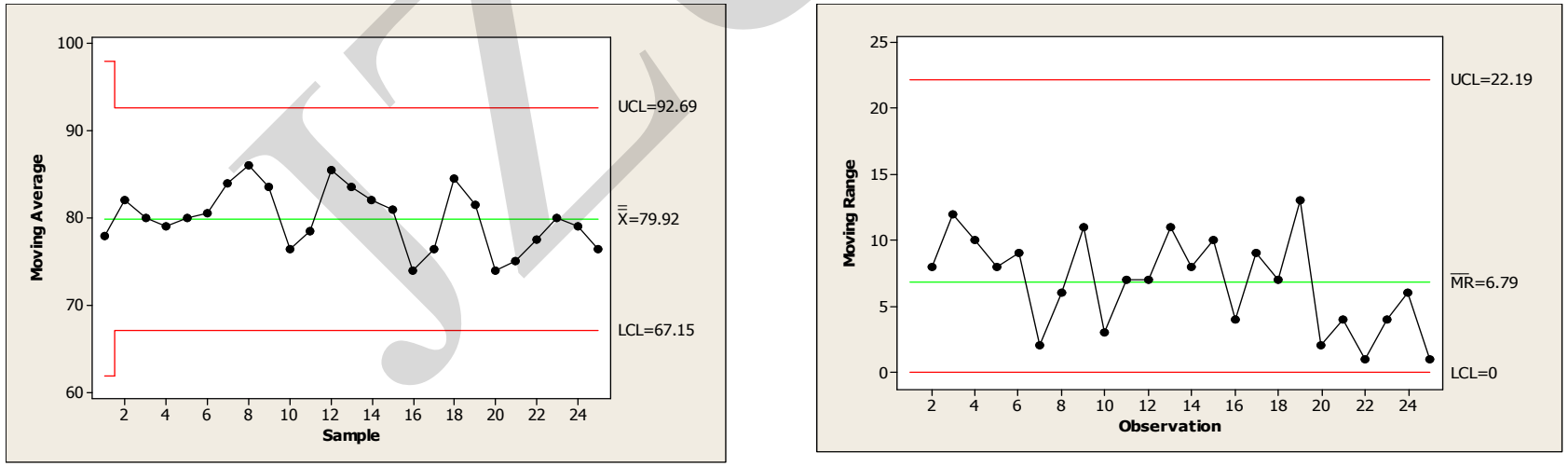

Fig. 4 The MA-MR control charts for SVI .

A mathematical relationship is developed for both turbidity, y_1, and SVI, y_2, with the critical process factors. Based on process knowledge, the main controllable process factors thought to affect the wastewater quality characteristics are flocculant dose, coagulant dose, and pH. Design of experiment is then conducted to optimize process performance.

The weighted additive model is employed to obtain the optimal values of process factor settings while considering the preferences of process/product engineers. The summary of the control chart results are displayed in Tables 1 and 2 for control charts and process capability, respectively.

Table 1. Improvement summary using control charts.

Response		Moving average (MA)			Moving range (MR)		
		UCL	CL	LCL	UCL	CL	LCL
y_1	Before	24.81	20.22	15.64	7.964	2.438	0.0
	After	9.116	6.42	3.724	4.683	1.433	0.0
y_2	Before	92.69	79.92	67.15	22.19	6.79	0.0
	After	79.34	72.15	64.97	12.48	3.82	0.0

Table 2. Improvement summary using capability index.

Parameters	Turbidity*	SVI
LSL	0	50
USL	30	100
Mean	20.22(6.42)	79.69(72.15)
Standard deviation	2.16 (1.27)	6.02 (3.39)
Actual capability	1.34 (5.5)	1.46 (1.93)
Capability of whole product	1.95 (10.6)	