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SUSTAINABLE ENVIRONMENTAL SANITATION AND WATER SERVICES

Optimization of the use of Flocculants in Operation & Maintenance of Water Treatment Plant - GRWW (Phase - II) Experience

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Introduction

Due to rapid growth of population, demand for potable water is ever increasing. Not only the common people, the industries also consume a considerable amount of water. Particularly in the urban areas whose growth is rapid, dense population and industrial clusters generally draw a huge amount of potable water.

At present there are two types of water source, from which potable water is drawn. Those are, surface water source and ground water source. Water from ground sources is readily available, hence the water works needs less capital cost. Treatment procedure is also simple and less capital intensive. But the amount of ground water is not unlimited, particularly it is extremely difficult to supply enough ground water in a large urban agglomeration. Morever, due to some geological reasons and imbalance between recharge and withdrawal of groundwater due to intensive crop cultivation, arsenic contamination plays havoc with a large population, especially in the eastern part of our country.

Due to these reasons, surface water is getting importance to combat the need-for potable water. But the supply of potable water from a surface source is capital intensive, because collection and treatment of surface water need various units of water transport and treatment.

Not only the cost of construction, operation and maintenance also needs a considerable amount of monitory investment. In most of the surface water treatment plants, besides the personnel expenditure, energy cost pervades most of the O & M budget Cost of chemicals, i.e., flocculants and disinfectants, trails behind the energy cost. Energy cost, which can be primarily governed at the time of planning, is difficult to reduce except by the proper operational management. But the cost of chemical, particularly flocculants, can be reduced to some extent by taking some technical surveillance over the O & M procedures of water treatment. These types of surveillance are being practiced at Garden Reach water Works, Phase-II, and immediate benefits are obtained.

Plant Description

Garden Reach Water Works (Phase-II) with a capacity of 60 MGD, is the biggest water treatment plant within India commissioned at the beginning of second millenium. This plant is for meeting the potable water demand for a population of 30.43 lakhs (year 2015) for the area extending from Baghajatin area of KMC in the East to Pujali in the West, Garden Reach unit of KMC in the North to Maheshtala municipality and South Suburban unit of KMC in the South.

Though the capacity of this plant is 60 MGD, due to the presence of similar plant (Garden Reach Water Works, Phase – I) adjacent to this, and lesser need of potable water at present, amount of water treated varies from 20 MGD to 52 MGD according to the demand. Therefore, it is obvious that the plant is running intermittently and generally in two shifts. But most of the time, this plant is running overloaded by 12% to 16%.

GRWW (Phase-II) is a treatment plant with Rapid Sand Filtration system, for which flocculation is an essential pre-treatment process. The raw water comes from the river Hoogly through a GRP pipe within the plant. At first chlorine is injected into the raw water followed by the alum dosing. Then the raw water goes through flash mixer, clariflocculator and filter beds successively. After that, again chlorine is injected into the treated water as disinfectant and to get residual chlorine at the far end of water distribution network.

Cutting the Expenditure

From the very beginning, after the commissioning of Garden Reach Water Works (Phase-II) with a capacity of 60 MGD, the necessity to cut the cost of operation and maintenance in every respect was being felt. For that purpose, the primary attempt has been taken to reduce the cost of flocculants, which is the concern of this paper. The optimization technique adopted here is being applied only from the field experience and the way the plant behaves in accordance with the characteristics of incoming raw water.

Methodology

In this water treatment plant, chemical coagulation is required as a pre-treatment prior to the filtration. Coagulation is a two-step process involving destabilization followed by particle transport to promote collisions between the destabilized particles.

Destabilization is induced by the addition of a suitable coagulant, and particle contact is ensured through appropriate mixing devices. In a typical water treatment plant coagulation occurs in the rapid-mixing and flocculation units.

The main chemical coagulant which is being used in this treatment plant (as also in most of treatment plants of our country) is ferric alum, where desired water soluble Al(III) and Fe(III) content (as per IS: 299-1989) should be 16.0% and 0.7% respectively. Aluminium(III) and iron(III) accomplish destabilization by two mechanisms : (1) adsorption and charge neutralization and (2) enmeshment in a sweep floc. If an Al(III) or Fe(III) salt is added to water in concentration less than the solubility limit of the metal hydroxide, the hydrolysis products will form and adsorb onto particles, causing desabilization by charge neutralization. When the Al(III) or Fe(III) added to water is sufficient to exceed the solubility of the metal hydroxide, the hydrolysis products will form as kinetic intermediates in the formation of the metal hydroxide precipitate. In this situation charge neutralization and enmeshment in the precipitate both contribute to coagulation. Interrelation between pH, coagulant dosage, and colloid concentration determine the mechanism responsible for coagulation [1].

This ferric alum is procured from renowned or local manufacturers. Generally, ISI-marked ferric alum is always preferred (conforming IS: 299-1989), but under adverse situation sometimes procuring of non-ISI marked alum is unavoidable. In this plant, during the last one year whenever non-ISI-marked alum was used, it did never show much deterioration in clarified water quality in comparison to ISI-marked alum, although it was seen that portion of insoluble matter in non-ISI marked alum might reach up to 6%.

In this paper, attention is focussed on the period between the months of July '01 and August '02. Within this period, the raw water turbidity rises up to 800 NTU in monsoon and sinks down to 40 NTU in winter. This period of transition of raw water turbidity helped us to understand the nature of raw water and how it reacts with chlorine and alum.

The variation of raw water turbidity is depicted in Figure-1. It shows that the maximum turbidity occurs in monsoon and minimum in winter. But in monsoon months the variation of raw water turbidity is wide, on the contrary, in winter months this variation is narrow. It is noted that in monsoon period, particularly in post-monsoon period, turbidity of raw water may vary widely within a short period, even in few hours. Whereas in winter period, this turbidity value is quite predictable without much variation. It is also worth mentioning that the pH value of the raw water is also quite favourable to the use of alum. Average pH value of the raw water is about 7.6 with no considerable variation. Maximum and minimum pH values were observed as 7.26 and 7.99 respectively but occurrence of such extreme values was rare.

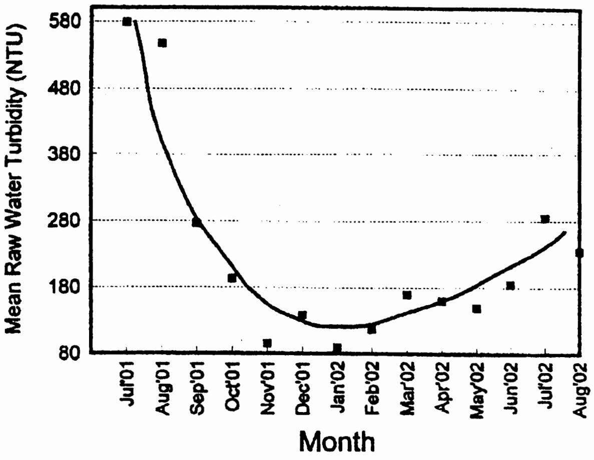

Figure -1 : Monthly variationof Mean Raw Water Turbidity

Due to this phenomenon, it was decided to take an hourly record of raw water quality, as well as to change the alum inflow depending on the raw water quality. The reason behind is two-fold. The primary reason is to optimise the usage of alum and secondary one to study the effect of varying alum dosing. The Jar test was carried on regularly once in a day and the test results was being compared with the field experiment results. To optimise the alum inflow into the raw water, two things were meticulously maintained. The first one was to maintain the turbidity of effluent water below 1.0 as per acceptable limit, and the second one to keep this value between 0.5 to 0.8. The reason behind the second was merely economical.

Apart from the flocculant dose, the velocity gradient of flash mixer and flocculator were also strictly maintained by the help of variable speed pulley. The minimum velocity gradient was being maintained as 300 per second and 20 per second for flash mixer and flocculator respectively.

The Results

The result of the field tests was astounding. It was noted that the results of Jar Test may not be the guiding criteria to fix up the alum flow into the raw water. It has been observed from the performance of the plant that there exists a factor between the turbidity of raw water after Jar Test and the turbidity of that after clarification. The value of this factor as observed is about 2.0 to 2.50. It is also observed that, if an environment almost similar to the prototype can be created at the Jar Test model

Table – 1

Month	Mean Turbidity (NTU)	Mean Alum Dose (ppm)	Mean Removal (%)
July 2001	578.06	26.15	98.82
August 2001	547.03	18.51	98.75
September 2001	276.63	9.69	96.58
October 2001	193.16	9.68	95.39
November 2001	95.33	6.65	91.61
December 2001	138.55	4.78	93.87
January 2002	89.23	6.26	89.91
February 2002	117.29	8.23	93.09
March 2002	170.14	9.03	95.36
April 2002	160.67	11.28	94.46
May 2002	150.07	7.83	93.94
June 2002	184.833	10.23	94.97
July 2002	285.00	23.41	96.84
August 2002	234.00	17.82	95.77

(mainly regarding detention time), the value of the factor remains almost unchanged. Moreover, though the plant operation was intermittent, this value was still unchanged after a prolonged running time.

The Table – 1 shows the mean values of alum doses and the percentage removal of turbidity. Even if we compare these values with other water treatment plants under K.M.W.S.A., comparatively lesser consumption of alum was observed. And even in this circumstance, alum consumption is reduced according to the removal of raw water turbidity.

These values also show a good correlation between themselves. The correlation factor obtained is 0.80 (using logarithm values), which shows a direct dependency of turbidity removal on alum dose. If we try to relate these two parameters by a non-linear equation, we shall get the following equation.

$$R = 86.119 \times A^{0.041}$$

Where, R = Percentage removal of turbidity in clariflocculator

A = Alum dose in raw water in ppm.

The graphical representation of this equation is depicted in the Figure – 2.

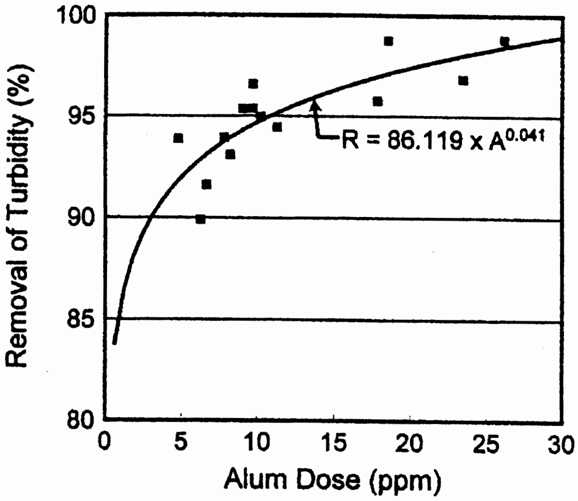

Figure -2 : Relation between Alum Dose and Removal of Turbidity

Conclusion

It has been observed from the past performances of this plant in comparison to the other treatment plants run under KMWSA that there is a remarkable reduction in consumption of ferric alum – the coagulant. The causes may identified as follows, 1) hourly monitoring of water quality vis-à-vis alum dose controlling, 2) better settling time due to intermittent operation, 3) favourable pH value of raw water for which no additional chemical is required to rise the pH, 4) proper pre-chlorination which has a definite influence on pH and thereby improve the flocculation performance. However, to arrive at a definite conclusion, the regular observation throughout the year on the performance of the treatment plant is warranted.

References

1. BENEFIELD, L., 1979, Process chemistry for water and wastewater, John Wiley & Sons.