Appropriate Destabilization of Settled Water of WTP

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Abstract— **Settled water, supernatant after the sedimentation tank or tube settler basin contains colloids, which are stable in nature. These colloids are in suspension and never agglomerate because of the more negative charge or zeta potential. This is a result of inadequate pretreatment, which results in unexpected poor performance of rapid sand filters. The zeta potential is a measure of surface charges on colloidal particles. Surface charges of particles are crucial for transport, agglomeration as well as attachment of particles to collecting sand grains. In this view an attempt is made in the present study to monitor zeta potential of particles in settled water of Water Treatment Plant at Miraj. The equipment Zeta Meter - 4, (U. S. A.) with computer interface and zeta potential software was used. It was found that the effluent turbidity as well as overall performance of rapid sand filters is strongly dependent of zeta potential of influent particles. Further the laboratory studies are carried out for destabilization of settled water by using various coagulants. The performance of coagulants for appropriate destabilization is evaluated based on their efficiency.**

Key words: Settled water; zeta potential; surface charge; pretreatment; rapid sand filter; destabilization; coagulants.

I. INTRODUCTION

Water is one of the essential constituents in our life. Natural surface waters contain inorganic and organic particles. Inorganic particles, including clay, silt, and mineral oxides, typically enter surface water by natural erosion processes. Organic particles may include viruses, bacteria, algae, protozoan cysts and oocysts, as well as detritus litter that have fallen into the water source. In addition, surface waters will contain very fine colloidal and dissolved organic constituents such as humic acids, a product of decay and leaching of organic debris. Particulate and dissolved organic matter is often identified as natural organic matter (NOM). Removal of particles is required because they can (1) reduce the clarity of water to unacceptable levels (i.e., cause turbidity) as well as impart color to water (aesthetic reasons), (2) be infectious agents (e.g., viruses, bacteria, and protozoa), and (3) have toxic compounds adsorbed to their external surfaces. [10]

Many impurities in water are present as colloidal dispersions, i.e. they occur in particulate form within the approximate size range 1 to 10-3 μm. Examples of this type of suspension include clays, substances of biological origin such as natural colour, proteins, carbohydrates and their natural or industrial derivatives. Invariably suspensions of this type possess an inherent stability or resistance to particle aggregation. They are not amenable to clarification by sedimentation due to their negligible settling velocity nor can they be removed by sand filtration processes. Their transformation to a flocculent condition is effected by the process of coagulation. Colloidal particles have a very high specific surface and consequently their behaviour in suspension is largely determined by surface properties, the gravitational influence on movement being relatively unimportant. Colloidal particles may be hydrophobic (clays, metal oxides) or hydrophilic (plant and animal residues, proteins, starch, detergents). Hydrophobic colloids have no affinity for water and are considered to derive their stability from the possession by individual particles of like charges, which repel each other. These charges may arise from the preferential adsorption of a single ion type on the particle surface or from the chemical structure of the particle surface itself. The possession of charge, positive or negative, by a colloid gives rise to its envelopment by an 'electrical double layer', resulting in a potential gradient in the particle vicinity. [7]

Coagulation is an essential component in the conventional water treatment practice. Coagulation, sedimentation, and filtration are used in series to remove particles and natural organic matter (NOM) from raw water. The primary aim of coagulation in conventional treatment is to destabilize particles so that they may combine into larger aggregates that will settle efficiently in the sedimentation process or be removed in the subsequent filtration process.

Coagulation is the process in which coagulants are added to water to reduce the electrostatic force of repulsion that tends to keep particles apart. Particles in source water are typically in a stable condition and will not form flocs when they collide, largely due to repulsive forces that stem from charges on the particle surfaces. The purpose of coagulation is to destabilize the particles and enable them to become attached to other particles so that they may be removed in sedimentation process.

According to Indian drinking water standards (IS 10500:2004) the acceptable limit of turbidity of water after treatment is 5 NTU and it is revised to 1 NTU according to Indian drinking water standards (IS 10500:2009, 2012). To achieve desired drinking water standards there is need to modify the conventional water treatment by adopting appropriate alterations. Post-sedimentation water from water treatment plant contains submicron particles including small colloids. These particles are unable to agglomerate, require large detention time for agglomeration and settling. By adopting coagulation to post-sedimentation water, these particles are destabilized i.e. zeta potential of these particles is so reduced that they can easily clump together and removed by adopting filtration. In this view, study conducted on the of settled water to assess the surface charges and attempts were made to destabilize settled water by post-sedimentation coagulation to make it appropriate for filtration.

II. MATERIALS AND METHODS

A. *Methodology adopted for sampling*

Settled water samples were collected from tube settler basin of Miraj water treatment plant. (WTP)

B. *Final Stage Coagulants used for destabilization*

Potassium alum ($KAl(SO_4)_2 \cdot 12H_2O$), Polyaluminium chloride (PAC), Cationic polymer CMF-90

C. *Determination of Turbidity*

Nephelometric Turbiditymeter was used for determination of turbidity.

D. *Laboratory Experimentation*

Jar test apparatus was used for determination of optimum coagulant dose. Jar tests were carried out on settled water from Miraj water treatment plant by using above mentioned coagulants at optimum pH. IF the Zeta Potential is reduced to near zero the repulsive forces are so reduced that the particles will tend to agglomerate and with continued agitation, will become large enough to settle. In this view, the initial zeta potential of settled water and zeta potential after destabilization was measured.

E. *Measurement of Zeta Potential*

Zeta meter 4.0 is equipment manufactured by Zeta-Meter, Inc. 765 Middlebrooks Avenue, USA. It was used for zeta potential measurement.

Fig.1 Zeta meter 4.0

III. RESULTS AND DISCUSSIONS

I. Settled water turbidity and Zeta potential observations-

Settled water samples were collected from tube settler basin of Miraj WTP. Turbidity was determined with the help of Turbiditymeter and Zeta Potential was determined with help of Zeta-Meter. Following are the observations of Turbidity and Zeta potential of settled water

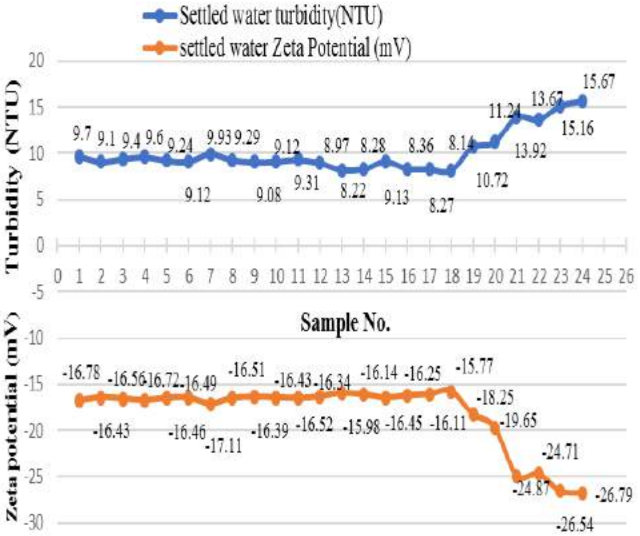

Fig.2 Representation of turbidity and zeta potential of settled water samples from Miraj WTP

Fig.2 indicates that the zeta potential of settled water is high enough i.e. -15 mV to -26 mV and turbidity ranges in between 9.0 NTU to 16 NTU.

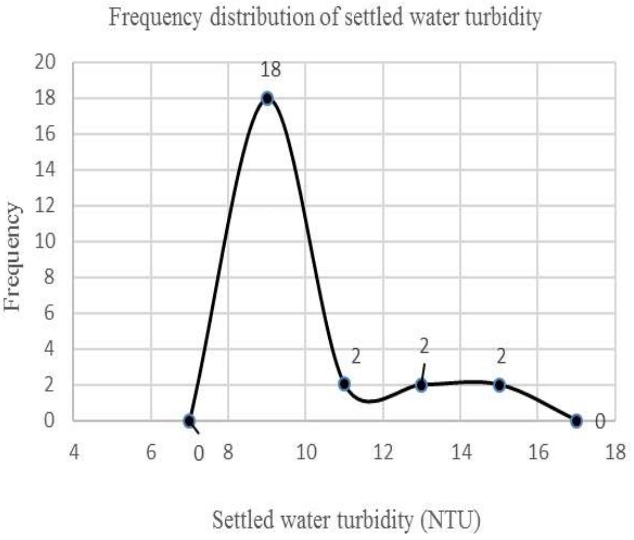

Fig.3 Frequency distribution of samples for settled water turbidity

Fig.3 shows frequency distribution of samples for settled water turbidity from Miraj WTP. It shows that out of 24 samples of settled water, 2 samples were in the range of 10 NTU to 12 NTU turbidity, 2 samples were in range of 12 NTU to 14 NTU turbidity and 2 samples were in 14 NTU to 16 NTU turbidity. From this Fig., it is indicated that most of the time turbidity of settled water was within range of 8 NTU to 10 NTU.

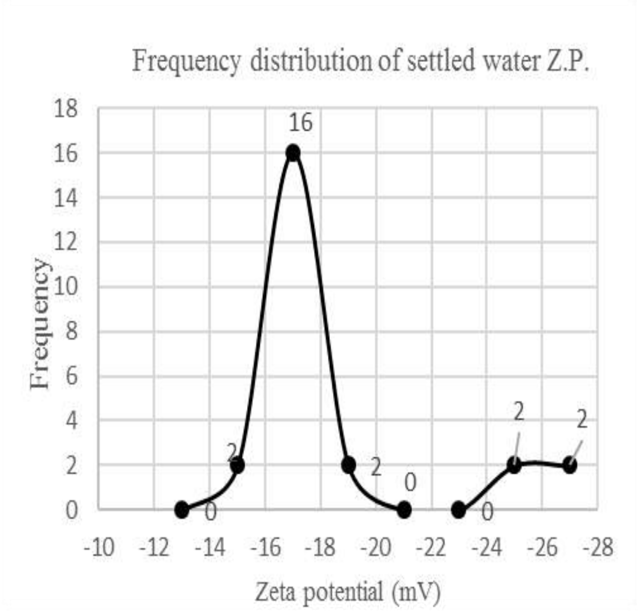

Fig.4 Frequency distribution of samples for settled water turbidity

Fig.4 shows frequency distribution of samples for settled water zeta potential from Miraj WTP. It shows that out of 24 samples of settled water 2 sample was in the range of zeta potential -14 mV to -16 mV, 16 samples were in the range of zeta potential -16 mV to -18 mV, 2 samples were in the range of zeta potential -18 mV to -20 mV, 2 samples were in the range of zeta potential -22 mV to -24 mV, 2 samples were in the range of zeta potential -24 mV to -26 mV and 2 samples were in the range of -26 mV to -28 mV zeta potential. From this Fig.3 it is indicated that most of the time zeta potential of settled water was within range of -16 mV to -18 mV.

II. Jar tests results

Jar tests were carried out on settled water from Miraj WTP to determine optimum coagulant required to reduce the zeta potential of settled water. Potassium alum and PAC and Cationic polymer CMF-90 were used as coagulants and their performance was observed. The dose of potassium alum was varied from 2 to 10 mg/l with the increment of 2 mg/l, the dose of PAC was varied from 0.2 to 1 mg/l with the increment of 0.2 mg/l and the dose of CMF-90 was varied from 0.1 to 0.5 mg/l with the increment of 0.1 mg/l. based on turbidity of settled water.

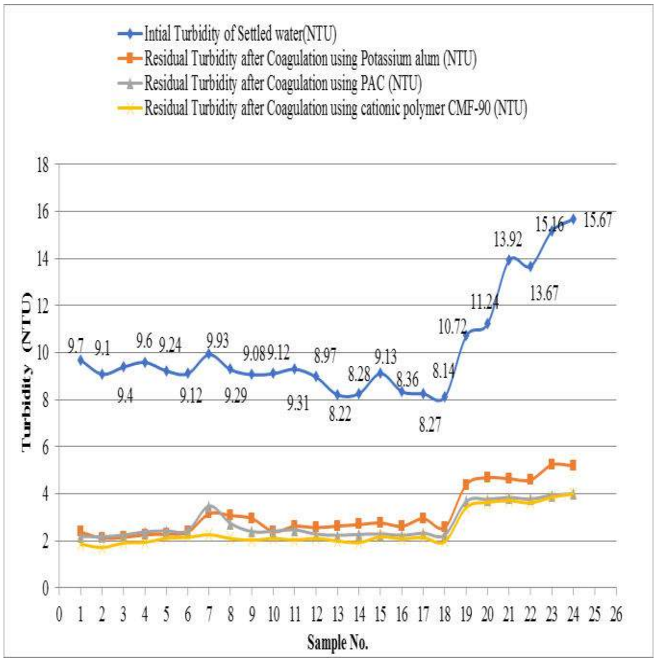

Fig.5 Representation of initial settled water turbidity and residual turbidity after coagulation using various coagulants

Fig.5 shows that, initial settled water turbidity was in the range 9.0 NTU to 16 NTU. It is reduced to 2 NTU to 5 NTU by using Potassium Alum ($Al_2(SO_4)_3\ 18H_2O$), PAC (polyaluminium chloride) and Cationic polymer CMF-90. The turbidity removal efficiency of settled water by using Cationic polymer CMF-90 as a coagulant is better as compared to PAC and Potassium alum

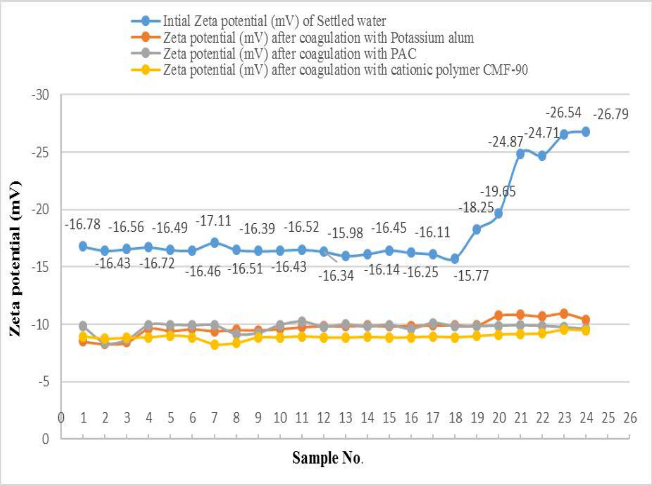

Fig.6 Representation of initial zeta potential of settled water and zeta potential after coagulation using various coagulants

Fig.6 shows that initial zeta potential of settled water was significantly high (-15 mV to -26 mV). It is reduced to -8 mV to -12 mV by using Potassium Alum ($Al_2(SO_4)_3\ 18H_2O$), PAC (polyaluminium chloride) and Cationic polymer CMF-90. The efficiency of destabilization of settled water by using Cationic polymer CMF-90 as a coagulant is better as compared to PAC and Potassium alum.

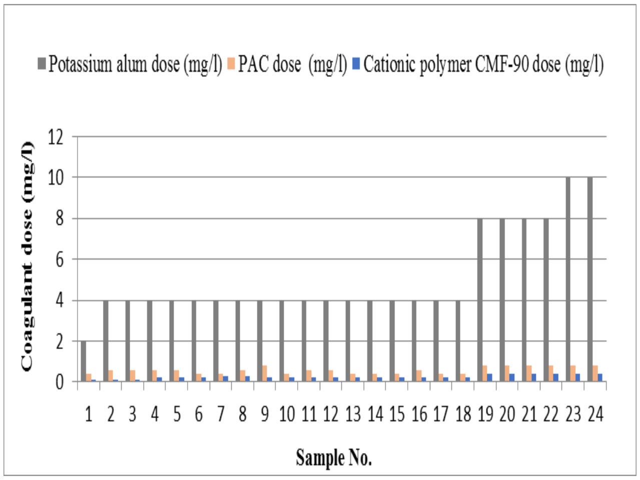

Fig.7 Coagulant dose required for destabilization of settled water

Fig.7 shows the overall representation of coagulant dose required for destabilization of settled water It is observed that for adequate destabilization of settled water from Miraj WTP, the dose Potassium alum was in the range 2-10 mg/l, the dose of PAC was in the range 0.2-0.8 mg/l and the dose of cationic polymer CMF-90 was in the 0.1- 0.4 mg/l. Therefore, the dose of cationic polymer for adequate destabilization of settled water was less as compared to PAC and Potassium alum.

IV. CONCLUSION

- Based on observations for settled water from Miraj WTP, it is found that zeta potential of was significantly high (-15 mV to -26 mV) indicating suboptimal coagulation.

- By using a coagulant such as Potassium alum, PAC, or cationic polymer CMF-90 for further destabilization of settled water from Miraj WTP, zeta potential of settled water could be reduced (-8 mV to -12 mV) in order to increase filterability.

- It is found that doses required for adequate destabilization of settled water from Miraj WTP were 2-10, 0.2-0.8, and, 0.1- 0.4 mg/l, respectively for Potassium alum, PAC and CMF-90.

- Destabilization performance cationic polymer CMF-90 as a coagulant was better than Potassium alum and PAC and doses of Cationic polymer CMF-90 required for destabilization to desired extent were less

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