© 2017 IJSRST | Volume 3 | Issue 3 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Coagulation for Wastewater Treatment : A Review on Investigations and Studies

Sunil Jayant Kulkarni

Chemical Engineering Department, Datta Meghe College of Engineering, Airoli, Navi Mumbai, Maharashtra, India

ABSTRACT

Chemical treatment of wastewater can be carried out with the help of different coagulants, flocculating and precipitating agents. Coagulation is one of the most important chemical treatments. Various investigators have carried out investigation on coagulation aimed at studying selection of coagulant, optimization of affecting parameters and combinations with other treatment methods. Current review is aimed at summarizing research and studies on coagulation. Many investigators recommended use of polymer-based coagulant. Coagulants like chitosan and moringa seeds indicated good coagulation properties. Coagulation combined with ultra- or microfiltration improved the treatment process of water with higher organic matter load. Selection of coagulating agent and proper combination of coagulation with other physicochemical treatment can lead to highly effective, economical and efficient solution for wastewater treatment.

Keywords: Coagulant, Particle Size, Membrane Separation, Hybrid Method, Removal, Suspended Matter.

I. INTRODUCTION

Wastewater treatment in chemical, pharmaceutical, paint, cement, mining, petroleum and many other industries is becoming important area of research due to increasing awareness about pollution and scarcity driven need for recycle. The domestic wastewater treatment is also major concern for civil society. The conventional treatment plant contains primary treatment with screens, primary sedimentation and other physical treatment steps. The secondary treatment contains biological treatment. The biological treatment methods are divided into suspended growth and attached growth processes. Activated sludge process is widely used biological treatment method [1-4]. In this the organic matter is stabilized. The biological treatment can be aerobic and anaerobic. Anaerobic method reduces space requirement and produces methane gas, which has fuel value [5-8]. Trickling filter treatment is important attached growth method [9, 10]. The membrane separation methods are costly but effective [11, 12]. The membrane separation methods are normally used as tertiary or higher treatment methods in treatment train. Adsorption can be used for removal of various pollutants from wastewater [13,14]. Chemical treatment of wastewater can be carried out with the help of different coagulants, flocculating and precipitating agents. Coagulation is one of the most important chemical treatments. Various investigators have carried out investigation on coagulation aimed at selection of coagulant, optimization of affecting parameters and combinations with other treatment methods. Current review is aimed at summarizing research and studies on coagulation.

II. COAGULATION FOR WASTEWATER TREATMENT: A REVIEW ON INVESTIGATIONS AND STUDIES

Zueva et.al studied coagulation treatment for wastewater of meat industry [15]. They carried out experiments on wastewater treatment with coagulants and so coagulant aids. They considered the meat industry wastewater as a dispersed system (suspension). They observed that Aluminum sulfate at low pH (<7, 8) form positively charged sol of aluminum hydroxide. It neutralized negatively charged particles in wastewater as above pH 7 nano-particles in a sol-gel system are charged negatively. For aluminum sulphate, the fats removal was much more effective than adsorption of iron salts. They used an inorganic sorbent and alumnum sulfate jointly to increase the value of Zeta potential and the effectiveness of purification almost twice. According to

them, dual aluminum sulfate – alumina systems can markedly enhance coagulation at a much lower dosage.

Jin carried out investigation on use of a high resolution photographic technique for studying coagulation/flocculation in water treatment [16]. Generally a microscopic image technique is used in the coagulation and flocculation process. According to them the sample handling disturbs the floc characteristics during measurement. To evaluate flocculation processes, they proposed a high resolution photographic technique. By using this technique, they obtained images of flocs directly while the flocculation process was taking place. By using camera control software and particle size analysis software, this method provided a convenient means of gathering data to calculate size distribution. Angreni carried out review on optimization of conventional drinking water treatment plant [17]. According to them overdosing in coagulation can be avoided by using jar test. Fouling or clogging of injectors or diffusers and side reactions are other problems in coagulation. Intra cell baffles and tapered coagulation can minimize these problems. They divided parameters into two groups, raw water quality and parameters relative to conditions of process. A Review on applications of coagulation flocculation and ballast flocculation was carried out by Borchate et.al.[18]. According to these studies the use ballast flocculation serves for floc formation and ballast to increase floc density and settling velocity. It can reduce clarifier surface area. In this process, micro floc particles are formed with a specific gravity of greater than two. This process uses continuously recycled media and a variety of additives to improve the settling properties of suspended solids. In this processes ferric sulfate, an anionic polymer can be used as coagulants, and a ballast material such as micro sand, a micro carrier, or chemically enhanced sludge can be employed.

Bergamasco et.al. carried out investigation on coagulation/ flocculation and membrane filtration hybrid process for water treatment[19]. They used natural coagulants like chitosan and moringa seeds. They combined coagulation process with membrane filtration process (micro and ultrafiltration).They observed that permeate quality was increased as compared to individually operated systems. Also the study indicated that applying CF-MF/UF at optimum conditions, 100% removal of total coliforms, E. coli, Giardia and Cryptosporidium was obtained due to a hygienic barrier effect .They concluded that chitosan and Moringa oleifera have a potential application as natural coagulants in CF-MF/UF hybrid processes. Marble processing wastewater was treated by coagulation/flocculation /Sedimentation methods by Domopoulou et.al.[20]. They investigated the optimum conditions for the maximum solid waste removal. In their investigation they examined hydrated metal salts including$Al_2(SO_4)_3$,.$18H_2O$, $FeCl_3.6H_2O$ and $FeSO_4.7H_2O$ for their turbidity removal capacity under various dosages. According to the jar test carried out by them $FeCl_3.6H_2O$ presented the highest turbidity removal ability. $FeSO_4.7H_2O$ exhibited poor results.

A review was carried out by Ghernaout and Boucherit for natural organic matter (NOM) removal from water [21]. Instant and efficient dispersion of coagulant species into raw water is objective behind rapid mixing. According to them mechanical mixing is not sufficient for an instantaneous and uniform coagulant dispersion. They proposed pump diffusion mixer (PDM) for this purpose. They found that at lower coagulant dosage, in-line hydraulic jet and static mixers were able to achieve performance equivalent to that of the mechanical mixing type. According to them, chemical coagulation(CC) using in-line hydraulic jet mixer such as pump diffusion mixer, PDM was a reasonable method for the improvement of coagulation process. Hassanien carried out investigation on physic chemical treatment of water[22]. He attempted improvement in the quality of town water by application of alternating current, direct current and magnetic field . He used these methods as pre-treatment to enhance the coagulation and flocculation. In his investigation he observed that coagulation of natural colloids and other material suspended in water was faster in water impacted by an electric current. Also he found that there were small changes in pH, total dissolved solids, conductivity and temperature of water after treatment. The considerable decrease was obtained in the parameters like turbidity, total suspended solids and hardness.

Bahadori et. al. studied coagulation and flocculation process design [23]. The effect of these two processes causes' small pollutant particles such as metals to aggregate and form large enough floc. According to

them, three types of coagulants are electrolytes, organic polymers and synthetic polyelectrolytes. They also discussed choice of coagulant. According to them, the type and quality of water, variations in the quality of the raw water, quality requirements and use of the treated water, nature of the treatment after coagulation and degree of purity of reagents are determinants in choice of coagulants. Sostar-Turk et.al. carried out investigation on coagulation and membrane filtration processes for laundry wastewater treatment [24]. They carried out wastewater treatment with conventional method with precipitation/coagulation and the flocculation process with adsorption on granular-activated carbon (GAC). They also proposed alternative method with membrane filtrations, namely ultrafiltration (UF) and reverse osmosis (RO). Their analysis of untreated water indicated that temperature, pH, sediment substances, total nitrogen and phosphorous, COD, BOD_5 and the amount of anion surfactants were above the regulatory limits. They found that permeate coming from RO met the required regulation as well as requirements for reusing in washing process. The limiting factor was the cost of membrane processes compared to the GAC treatment process.

Prakash et.al. treated waste water by coagulation and flocculation [25]. According to them, there is considerable variation in properties such as source, composition charge, particle size, shape, and density. In their investigation they used coagulants such as alum, ferric chloride and ferrous sulphate. They carried out experiments under optimum conditions of pH and coagulant dosage. They found that alum was most efficient with removal percentage of 98.9. The optimum pH value for treatment was 7. Farajnezhad and Gharbani used poly aluminum chloride and ferric chloride as coagulants for petroleum wastewater treatment [26]. They observed that poly aluminum chloride was more efficient. Also the flocs formed by poly aluminum chloride were larger than flocculated formed by ferric chloride. The research also indicated that pH had no significant effect on color removal of petroleum wastewater. Sahu and Chaudhari reviewed chemical wastewater treatment used for industrial wastewater [27]. According to them use of inorganic salts and polymeric organic coagulants is common for potable water. According to them, the most important factor in coagulation is the selection of coagulation. In their opinion, the important disadvantage of the coagulation is generation of large quantities of chemical sludge and its classification as hazardous waste. Coagulation can bring about solids removals of about 90% as compared to about 35% without coagulation ahead of gravity settling.

Desai and Sahu carried out comparative study of polymer and regular coagulant [28]. They treated municipal wastewater. In their studies they found that polymer-based coagulant and flocculent agent was able to achieve turbidity removal (almost 100%, depending on the dosage) and around 50% of BOD_5 and COD removal. They concluded that polymer-based coagulant and flocculent agents were quite effective coagulant and flocculent agent. They also found that sludge production was reasonably within normal ranges. Farhaoui and Derraz reviewed optimization of drinking water treatment process[29]. According to them optimization can decrease the managing and monitoring expenses and improve the quality of the produced water. They proposed the use of sludge as coagulant aid with the aluminum sulfate. It can reduce aluminum sulfate dosage. By using this approach, the aluminum sulfate dose required was reduced to 40% of the conventional requirement. Also it reduced the sludge volume. The combination of coagulation and low-pressure membrane filtration was used by Konieczny et.al. for wastewater treatment [30]. They used UF/MF and a hybrid process coagulation–UF/MF. They used capillary modules made of polyethersulfone (PES) for ultrafiltration and of polypropylene (PP) for microfiltration. Iron chloride ($FeCl_3 \cdot 6H_2O$) and aluminum sulfate ($Al_2(SO_4)_3 \cdot 18H_2O$) were used as coagulants. The hybrid treatment included coagulation–sedimentation–MF/UF and in-line coagulation (without sedimentation)–MF/UF systems. They observed that coagulation combined with ultra- or microfiltration improved the treatment process of water with higher organic matter load. According to these studies, in-line coagulation arrangements were more effective. This arrangement saved space and also reduced the amount of coagulant used. Ahamad et.al. used coagulation and flocculation processes for separating the suspended solids portion from water[31]. They studied the impact of pre-sedimentation on optimum coagulant dosage. They determined optimum alum doses at optimum pH and alkalinity.

III. CONCLUSION

Chemical treatment of wastewater can be carried out with the help of different coagulants, flocculating and precipitating agents. Coagulation is one of the most important chemical treatments. Investigations indicated that for meat wastewater dual aluminum sulfate – alumina systems can markedly enhance coagulation at a much lower dosage. Studies also indicated that intra cell baffles and tapered coagulation can reduce fouling or clogging of injectors or diffusers and side reactions. Studies also revealed that coagulation combined with ultra- or microfiltration improved the treatment process of water with higher organic matter load.

Many investigators recommended use of polymer-based coagulant. Coagulants like chitosan and moringa seeds indicated good coagulation properties. It can be concluded that selection of coagulating agent and proper combination of coagulation with other physicochemical treatment can lead to highly effective, economical and efficient solution for wastewater treatment.

IV. REFERENCES

[1]. Pallavi Amale, Sunil Kulkarni, Kavita Kulkarni(2014)., Studies on Packed Bed Treatment for Organic Matter in Distillery Effluent. International Journal of Engineering Science and Innovative Technology (IJESIT), 3(5), pp. 268-272.

[2]. Sonali Dhokpande, Sunil Kulkarni , Dr. Jayant Kaware(2016). Characterization of Activated Sludge and Electroplating Effluent. International Journal of Scientific Engineering and Applied Science (IJSEAS), 2(5), pp.294-297.

[3]. Sonali Dhokpande, Dr. Jayant Kaware, Sunil Kulkarni(2014)., Activated Sludge for Heavy Metal Removal-A Review. International Journal For Research In Applied Science And Engineering Technology. 2(7), pp.254-259.

[4]. Takaaki Tokutomi)2013). New Aerobic And Anaerobic Wastewater Treatment Process And Reclamation Of Wastewater. Foods & Food Ingredients J. Jpn., 218, (2), pp.1-2.

[5]. Sunil J. Kulkarni, Pallavi M. Kherde(2015). Research on Advanced Biological Effluent Treatment: A Review. International Journal of Research and Review, 2(8), pp. 508-5012.

[6]. Lew, S. Tarre, M. Belavski And M. Green(2004). UASB Reactor For Domestic Wastewater Treatment At Low Temperatures: A Comparison Between A Classical UASB And Hybrid UASB-Filter Reactor. Water Science And Technology, 49(11), pp. 295–301.

[7]. E. Gasparikova, S. Kapusta, I. Bodík, J. Derco, K. Kratochvíl(2005). Evaluation Of Anaerobic-Aerobic Wastewater Treatment Plant Operations. Polish Journal Of Environmental Studies, 14(1), pp. 29-34.

[8]. A. Britton, F.A. Koch, D.S. Mavinic, A. Adnan, W.K. Oldham, And B. Udala(2005). Pilot-Scale Struvite Recovery From Anaerobic Digester Supernatant At An Enhanced Biological Phosphorus Removal Wastewater Treatment Plant. J. Environ. Eng. Sci., 4, pp.265–277.

[9]. Sonali R. Dhokpande, Sunil J. Kulkarni, Dr. Jayant P. Kaware(2014). A review on research on application of trickling filters in removal of various pollutants from effluent. International Journal Of Engineering Sciences & Research Technology,3(7), pp.359-365.

[10]. Khantong Soontarapa and Nuntachai Srinapawong(2001). Combined membrane-trickling filter waste water treatment system, J. Sci. Res. Chula. Univ., 26(2), pp. 59-71.

[11]. Pawar Avinash Shivajirao (2012). Treatment of distillery wastewater using membrane technologies. International Journal of Advanced Engineering Research and Studies, 1(3), pp. 275- 283.

[12]. Sunil J. Kulkarni, Ajaygiri K. Goswami (2014). Applications and advancements in treatment of waste water by membrane technology- a review. International Journal of Engineering Sciences and Research Technology, 3(9), pp.446-450.

[13]. Sunil J. Kulkarni(2014). Modeling for Adsorption Columns for Wastewater Treatment: a Review. International Journal of Innovative Research in Engineering and Multidisciplinary Physical Sciences (IJIRMPS), 2(2), pp.7-11.

[14]. Sunil J. Kulkarni(2013). Removal Of Organic Matter From Domestic Waste Water By Adsorption.International Journal Of Science, Engineering And Technology Research, 2(10), pp.1836-1839.

[15]. Zueva SB, Ostrikov AN, Ilyina NM, De Michelis I and Vegliò F(2013). Coagulation Processes for

Treatment of Waste Water from Meat Industry. Int J Waste Resources, 3(2), pp.1-4.

[16]. Yan Jin(2005)., Use of a High Resolution Photographic Technique For Studying Coagulation/Flocculation In Water Treatment. A Thesis Submitted to the College of Graduate Studies and Research in Partial Fulfillment of the Requirements for the Degree of Master of Science in the Department of Civil and Geological Engineering University of Saskatchewan Saskatoon, May 2005, pp. 1-152.

[17]. Endah Angreni(2009). Review on Optimization of Conventional Drinking Water Treatment Plant.World Applied Sciences Journal, 7 (9), pp.1144-1151.

[18]. Borchate S.S., Kulkarni G.S.,Kore V. S., Kore S.V.(2014). A Review on Applications of Coagulation Flocculation and Ballast Flocculation for Water and Wastewater. International Journal of Innovations in Engineering and Technology (IJIET), 4(4), pp.216-223.

[19]. Rosangela Bergamasco, Angélica Marquetotti Salcedo Vieira, Letícia Nishi, Álvaro Alberto de Araújo and Gabriel Francisco da Silva(2012). Application of Hybrid Process of Coagulation/ Flocculation and Membrane Filtration to Water Treatment. Ecological Water Quality – Water Treatment and Reuse, Intechopen, pp.287-310.

[20]. Asimina E. Domopoulou, Konstantinos H. Gudulas, Efthimios S. Papastergiadis,Vayos G. Karayannis(2015).Coagulation/Flocculation/Sedim entation Applied to Marble Processing Wastewater Treatment. Modern Applied Science, 9(6), pp.137-144.

[21]. Djamel Ghernaout and Ahmed Boucherit(2015. Review of Coagulation's Rapid Mixing for NOM Removal. Journal of Research & Developments in Chemistry, Vol. 2015 (2015), Article ID 926518, pp.1-32.

[22]. Wissal Ahmed Mahmoud Hassanien(2004). Physico-Chemical Pre-Treatment For Drinking Water. A Thesis Submitted In Fulfilment Of The Requirement For The Degree Of Doctor Of Philosophy In Chemistry, Department of Chemistry Faculty of Education University of Khartoum,August 2004, pp.1-177.

[23]. Bahadori, Alireza, Clark, Malcolm, Boyd, Bill 2013). Essentials of Water Systems Design in the Oil, Gas, and Chemical Processing Industries. Springer Briefs in Applied Sciences and Technology, DOI: 10.1007/978-1-4614-6516-4_2, pp.21-41.

[24]. Sonja Sostar-Turk,Irena Petrinic,M. Simonic (2005). Laundry wastewater treatment using coagulation and membrane filtration.Resources Conservation and Recycling•May2005,DOI:10.1016/j.resconrec.2004 .11.002, pp.1-21.

[25]. N.B.Prakash, Vimala Sockan, P.Jayakaran(2014). Waste Water Treatment by Coagulation and Flocculation. International Journal of Engineering Science and Innovative Technology (IJESIT), 3(2), pp.479-484.

[26]. Hamidreza Farajnezhad, Parvin Gharbani (2012).Coagulation Treatment Of Wastewater In Petroleum Industry Using Poly Aluminum Chloride And Ferric Chloride. Int Journal of Research and Reviews in Appl. Sc. IJRRAS, 13 (1), pp.306-310.

[27]. O.P.Sahu, P.K.Chaudhari(2013). Review on Chemical treatment of Industrial Waste Water, J. Appl. Sci. Environ. Manage.,17 (2), pp.241-257.

[28]. Ronak Desai,Omprakash Sahu(2014). Comparatively Study of Polymer and Regular Coagulant for Municipal Waste Water Treatment.Journal of Applied Chemistry, 2 (1), pp.82-91

[29]. Mohamed Farhaoui, Mustapha Derraz(2016). Review on Optimization of Drinking Water Treatment Process. Journal of Water Resource and Protection, 8, pp.777-786

[30]. Krystyna Konieczny, Mariola Rajca, Michał Bodzek, Anna Kwiecińska(2009). Water Treatment Using Hybrid Method Of Coagulation And Low-Pressure Membrane Filtration. Environment Protection Engineering,35(1), pp. 5-22.

[31]. Kamal Uddin Ahamad, Debaraj Bailung Sonowal, Vivek Kumar, Neeraj Nikhil, Nirab Medhi(2014). Study on the impact of pre-sedimentation and consequently optimization of alum dose in water treatment process. Water Practice and Teachnology, 9(3), pp.417-429.