Australian Journal of Basic and Applied Sciences, 4(5): 887-892, 2010
ISSN 1991-8178

Comparing Copper Sulfate, Aluminum Sulfate and Ferric Chloride in Removing Microbial and Organic Contaminations in Municipal Waste Latex

Abolhassani, Z.M. and A. Astaraie

Department of Soil Science, Faculty of Agriculture, Ferdowsi University of Mashhad, P. O. Box 91775-1163. Mashhad, Iran.

Abstract: Since large amounts of municipal wastes and their environmental problems are one of major problems of our country, making use of special processes and methods to remove microbial and organic contaminations in latex of municipal wastes seems so essential that not only will soil fertility be increased but also spreading of pollution in environment will be prevented; however, it should be noted that this latex has useful nutrition for plant growth. Thus, in this study, coagulation process was used to remove microbial and organic contaminations in municipal waste latex. In Iran, copper sulfate, aluminum sulfate and ferric chloride are coagulants that have the most usages in purifying municipal water and sewage. In this study, a comparison was conducted between making use of these metallic salts in three concentrations of 15, 30 and 45 mg/l in reducing microbial contaminations (bacteria, fungi, mould, yeast and coliform) and organic contaminations (TOC) in municipal waste latex and optimum type and concentration of these salts in decreasing microbial and organic contaminations were determined. Results showed that metallic salts cause a reduction in microbial and organic contaminations and copper sulfate and ferric chloride had better performance than aluminum sulfate and that ferric chloride in concentration 30 mg/l was a better choice in compare to copper sulfate in reducing microbial and organic contaminations and aluminum sulfate was more effective only in reducing the number of fungi, mould and yeast.

Key words: microbial contamination, municipal waste latex, copper sulfate, aluminum sulfate and ferric chloride

INTRODUCTION

Today, garbage generation in large cities becomes so problematic; that is every person produces half kilo of garbage per day. If we assume that the population of people living in cities is 30 million, approximately 15 thousand tons of garbage is produced daily. If they are not removed according to hygienic principles, they will lead to some devastating environmental problems. On the other hand, if we look at the issue of waste positively and call it dirty gold, we can say that garbage is a valuable and recyclable matter. Waste can be changed to compost which is full of necessary organic matter and elements for plants. In the process of changing municipal waste to compost, a large amount of latex is produced. Although this latex is considered as one of the problems of making compost in Iran, it is a good source of water and nutrition. It contains essential and low-used elements (Fe, Zn, Mn, Cu) and is used in agriculture. Making use of this latex as compost is very important considering soil modification, fertility level, increasing qualitative and quantitative performance of agricultural products and saving water. Nevertheless, the latex has various microbial (bacteria, fungi, mould, yeast and coliform) and organic pollutants; it can enter the environment, ground water and soils and make them polluted. Therefore, removing these contaminations from municipal waste latex and reusing it in agriculture, we can reduce its harmful risks save fresh water. Coagulants are used in purifying water and sewage. Some coagulants that remove colloid particles by a special mechanism are metallic salts such as copper sulfate, ferric chloride, ferric sulfate, Ferro sulfate, cation, anion and nonionic organic polymers (Baes, C.F.J. and R.F. Mesner, 1976; Benschoten, J.E. and J.K. Edzwald, 1990; Gregor, J., C. Noke, 1997; Huang, C. and H. Shiu, 1996; Shahmansouri, M.R. and A.A. Neshat, 2003). No organic metallic salts make pollutants unstable and it occurred when electrical double layer around colloid particle is compressed and thus faster growth of particles and better isolation will be appeared (Lamer, V.K. and T.W. Healy, 1963). Coagulants are

Corresponding Author: Abolhassani, Z.M., Department of Soil Science, Faculty of Agriculture, Ferdowsi University of Mashhad, P. O. Box 91775-1163. Mashhad, Iran.
Email: mahboobeh_abolhasani@yahoo.com

often used in removing factors that produce turbidity. Factors which cause turbidity are of chemical, physical and biological origins (Benschoten, J.E. and J.K. Edzwald, 1990; Exall, K. and G. Vanloon, 2000; Montogomery, J.M., 1995; Rebhum, M. and M. Lurie, 1993). Total organic carbon (TOC) is one of the best indicators for recognizing organic contaminations (Montogomery, J.M., 1995; Omoike, A. and G. Vanloon, 1999) and to detect microbial contaminants, different microbial communities especially coliforms are used (Aguilar, I.M., J. Saez, 2003).

The aim of this study is to compare the performance of three metallic salts of copper sulfate, ferric chloride and aluminum sulfate and to determine the optimum concentration of these salts in reducing microbial (bacteria, fungi, mould, yeast and coliform) and organic (TOC) contaminations waste latex.

MATERIAL AND METHODS

To conduct this study, samples were collected from garbage latex produced in Mashhad compost factory. Then, they were transferred to laboratory for performing further experiments which include as follows:

At first, TOC and microbial communities (bacteria, fungi, mould, yeast and coliform) of samples were determined. Then, Jar test was done on them separately using three coagulants copper sulfate, ferric chloride and aluminum sulfate and optimum concentration of them were determined in removing turbidity (Kent, D.K., 1992) and reducing microbial communities. In this research, to determine the optimum concentration, injecting coagulating concentrations of 15, 30 and 45 mg/l are used.

The perform Jar test, initial fast mixture time, slow mixture time and sedimentation time were considered 1 min with 120 rpm, 15 min with 50 rpm and 30 min respectively (Kent, D.K., 1992; Wastewater, 1998). To determine the above mentioned amount of microbial communities, a special medium was used. To do this, the mediums PCA, PDA and EMB were used for growing bacteria, fungi and coliforme respectively. Since the amount of microbial communities was of importance considering quantity and possible number, the method of maximum possible number by preparing tenuity series was used. Mixed culture method was used to grow anaerobic and aerobic bacteria and the samples were stored in temperature 27 ^{0}C; the store time for growth of bacteria and coliforms were 72 hours and for fungi, mould and yeast were 164 hours. To determine the amount of TOC, combustion method with infra-red ray and TOC meter device of Micro NC type was used; to measure pH, direct measurement method with pH meter manufactured in Hack Company was used (APHA, AWWA, W.E.F., 1992; Gregor, J., C. Noke, 1997; Wastewater, 1998).

This experiments were set up in completely randomized design. Each treatment was replicated three times. Analysis of variance was performed on the data, and significant differences among treatment means were calculated by Duncan's multiple range test ($\alpha = 0.05$).

RESULTS AND DISCUSSION

In this research, some results were obtained that revealed the optimum type and concentration of metallic salts in reducing microbial (bacteria, fungi, mould, yeast and coliform) and organic contaminations or total organic carbon (TOC) in latex generated by making compost of municipal waste.

According to results, metallic salts (copper sulfate, ferric chloride and aluminum sulfate) were observed to significantly reduce all microbial communities (bacteria, fungi, mould, yeast and coliform) and TOC.

Flocculation is usually interpreted as the further agglomeration of slowly-settling coagulated particles into large rapidly-settling (or floating) floc upon the addition of an organic polyelectrolyte. Flocculant molecules attach and bridge between particles to form larger agglomerates. Polyelectrolyte flocculants are linear or branch chain organic polymers which form complex ions in solution (12).

A significantly difference was observed between the kind of salts in reducing number of bacteria, coliform and total microbial communities ($P<0.05$) and copper sulfate, ferric chloride and aluminum sulfate had the most effects respectively (Fig 1, 2, 3). According to results, there was a significantly difference between concentrations of different metallic salts in decreasing number of bacteria. Coliform and total microbial communities ($P>0.05$); ferric chloride in concentration of 30 mg/l and copper sulfate and aluminum sulfate in concentration 45 mg/l had the most effects.

The presence of organic matter generally increases the required coagulant dosage. It has been suggested that Al hydrolysis products from insoluble aluminumhumates or fulvates with humic substances, producing a colloidal sol that settles very slowly. At higher coagulant doses, the aluminum-organic complexes may be removed by incorporation into $Al(OH)_3$ flocs (1).

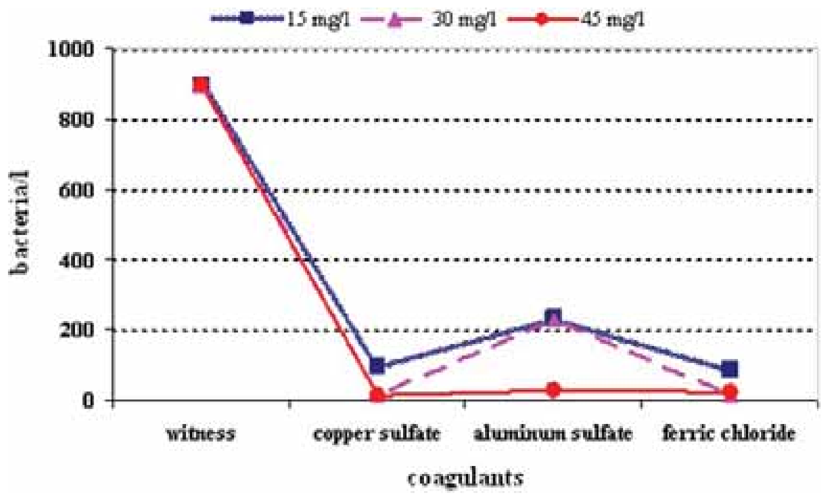

Fig. 1: Changes in number of bacteria by adding three coagulants in three concentrations of 15, 30 and 45 mg/l.

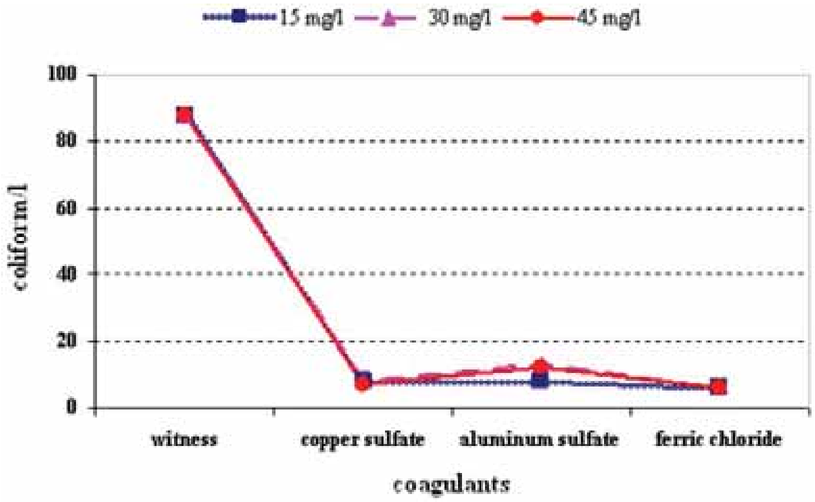

Fig. 2: Changes in number of coliform by adding three coagulants in three concentrations of 15, 30 and 45 mg/l.

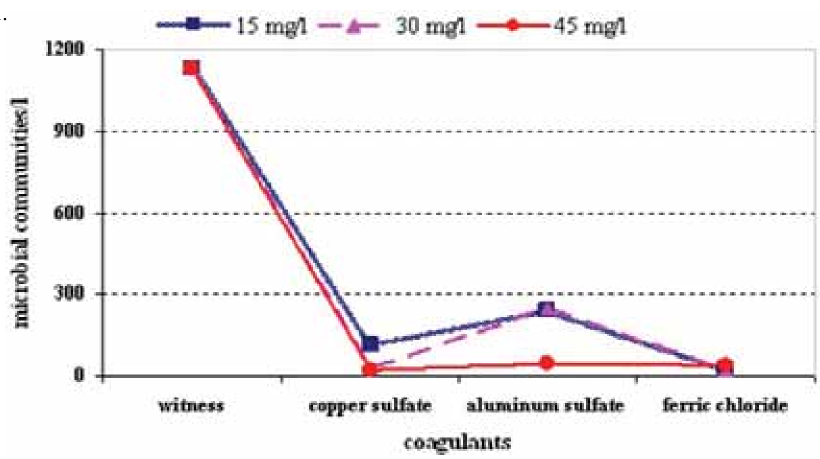

Fig. 3: Changes in number of microbial communities by adding three coagulants in three concentrations of 15, 30 and 45 mg/l.

Duan and Gregory investigated on coagulation by hydrolyzing aluminum and iron salts and their dependence on pH and coagulant dosage. They illustrated the hydrolysis constants for successive deprotonations in terns of following equations (9).

$$Me^{3+} + H_2O \rightleftharpoons Me(OH)^{2+} + H^+K_1$$

$$Me + (OH)^{2+} + H_2O \rightleftharpoons Me(OH)_2^+ + H^+K_2$$

$$Me + (OH)_2^+ + H_2O \rightleftharpoons Me(OH)_3 + H^+K_3$$

$$Me + (OH)_3 + H_2O \rightleftharpoons Me(OH)_4^- + H^+K_4$$

And for solubility constant:

$$Me(OH)_3 \rightleftharpoons Me^{+3} + 3OH^-K_2$$

Larsson, Walldal and Wall investigated the flocculation of large cationic polymers and nanosized particles. They found that the molecular architecture of the polymer (linear or branched) is essential for the flocculation behavior. Only in the case of the linear polymer, the degree of aggregation of the particle is important (16). Delgado and et al compared effectiveness of three inorganic coagulants-aluminum sulphate, ferric chloride and polyaluminum chloride (PAC)- in reducing the turbidity of secondary effluents from a conventional wastewater treatment plant. They showed that the optimal conditions are 50 mg/L corresponded to pH = 6 and a dose of PAC of 20 mg/ L , but the recommended conditions are 50 mg/L for pH = 6 to obtain a turbidity reduction of 90% (8). In present investigation, a novel formulation of coagulant/flocculant has been introduced and treated on effluent of two automotive factories (8).

The performances of aluminum sulfate, ferric chloride and poly-aluminum chloride in the removal of turbidity and organic substance. The optimum pH for coagulation is 6.0~7.0. Under optimal coagulating conditions, coagulation with ferric chloride is the best. It can also be seen that it's efficient to evaluate and choose coagulants with respect to turbidity and organic substance removal for increasing pollutant removal efficiency in coagulation and sedimentation (17).

The results obtained from the effects of these three coagulants on removing fungi, mould and yeast showed that reduction of fungi, mould and yeast by aluminum sulfate was better than that of copper sulfate and ferric chloride (Fig 4); however, no significantly difference was observed between various concentrations of aluminum sulfate in reducing the number of fungi, mould and yeast.

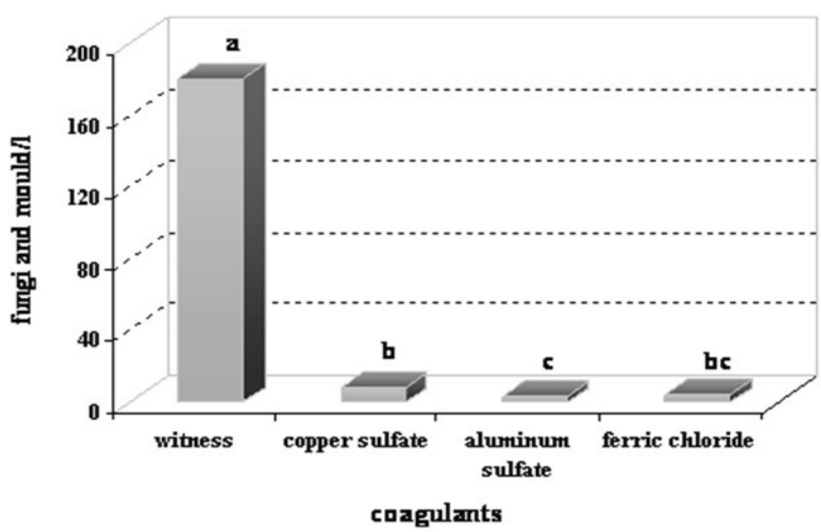

Fig. 4: Comparison of the average number of fungi, mould and yeast in municipal waste latex by adding three coagulants.

The removal of particles and organic matter from municipal waste latex is often achieved by coagulation, usually performed with iron, aluminum or copper salts. Coagulation can be interpreted as the conversion of colloidal and dispersal particles into small visible floc upon addition of a simple electrolyte. Increasing the concentration of the electrolyte results in a compression of the electrical double layer surrounding each suspended particle, a decrease in the magnitude of the repulsive interactions between particles and destabilization of the particles. The most common coagulant used in municipal waste latex treatment is alum Al_2 $(SO_4)_3$. $4H_2O$, copper sulfate and ferric chloride due to its effectiveness in treating a wide range of municipal waste latex type and relatively low cost. Inorganic coagulants are simple electrolytes which are water-soluble, low-molecular weight acids, bases, or salts. Additionally, the higher charge density of alum, copper sulfate and ferric chloride often results in a decrease in the coagulant dose and the associated solids production. Alum, alum, copper sulfate and ferric chloride function as a coagulant by initially forming positively charged Al and Fe species that adsorb to negatively charged natural particles resulting in charge neutralization.

Figure 5 shows that there is no significantly difference between types of salts in decreasing TOC ($P>0.05$); however, making use of metallic salts caused a significantly reduction in amount of TOC which is the indicator of organic contaminations ($P<0.05$). These results comply with the results achieved by Shahmansouri and Neshat on purifying water of Baba Sheijh Ali filtration in Esfahan in 2003, researches of Christian and *et al* in 2000 and . Svetlozar and *et al* in 2004. According to statistical evaluations of inlet and outlet concentrations of COD and TSS parameters of the CODISO during 2002-2003 period, the average inlet COD and TSS concentrations were 7020 and 1520 mg l-1 respectively (De-Feo, G., L. Rizzo, 2006). These values were in accord with the literature (Ates, E., D. Orhon, 1997).

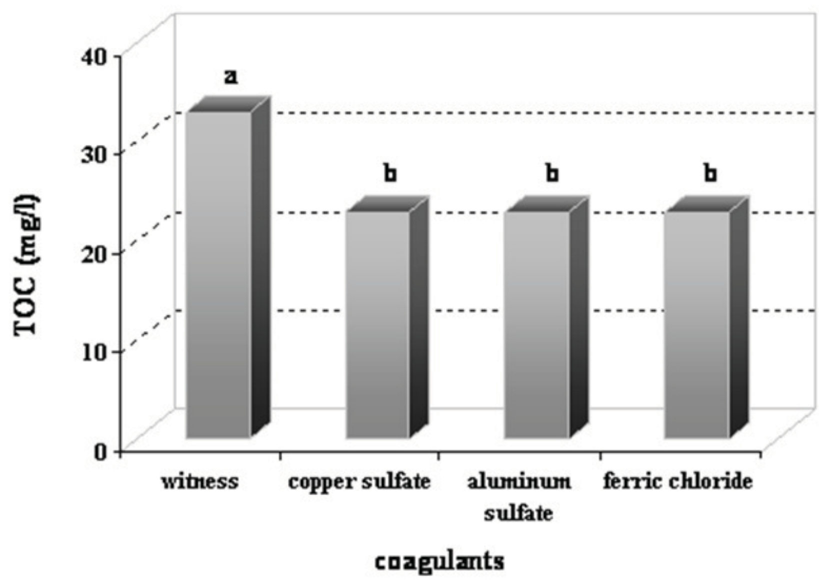

Fig. 5: Comparison of the average amount of total organic carbon in municipal waste latex by adding three coagulants.

In sum, results show that the best salt for decreasing the number of fungi, mould and yeast is aluminum sulfate; and ferric chloride with concentration of 30 mg/l is very good for decreasing bacteria coliform, total microbial communities and TOC. Therefore, due to reduction of total microbial communities and TOC, ferric chloride is considered the best choice in disinfecting and reducing organic and microbial communities in municipal waste latex.

ACKNOWLEDGMENTS

This investigation was supported by the department of soil science, Ferdowsi University of Mashhad, Iran, and International center for science and high technology and environmental sciences.

REFERENCES

Aguilar, I.M., J. Saez, M. Liorens, A. Soler and F.G. Ortuno, 2003. Microscopic observation of particle reduction in slaughterhouse wastewater by coagulation-flocculation using ferric sulfate as coagulant and different coagulant aids. Water Res., 37: 2233-2241.

APHA, AWWA, W.E.F., 1992. Standard methods for the examination of water and wastewater. 18^{th}, American public health association. Washington.

Ates, E., D. Orhon and O. Tunay, 1997. Characterization of tannery wastewaters for pretreatment-selected case studies. Wat. Sci. Tech., 36(2-3): 217-223.

Baes, C.F.J. and R.F. Mesner, 1976. The hydrolysis of cations. John Wiley & Sons. Inc.,New York.

Benschoten, J.E. and J.K. Edzwald, 1990. Chemical aspects of coagulation using aluminum salts. II.Coagulation of fulvic acid using alum and polyaluminum chloride, Water Res., 24(12): 1527-1535.

Christian, V. and *et al*., 2000. Impact of enhanced and optimized coagulation on removal of organic matter and biodegradable fraction in drinking water. Water Res., 34(12).

De-Feo, G., L. Rizzo, V. Belgiorno, S. Meric, 2006. Potential reuse of a leather tanning and an urban wastewater treatment plant effluent in Italy. Int.J.Environ. Poll. (in press).

Delgado, S., F. Diaz, D. Garcia and N. Oterto, 2003. Behavior of inorganic coagulants in secondary effluents from conventional wastewater treatment plant. Separat. Filter, 40: 43-46.

Duan, J. and J. Gregory, 2003. Coagulation by hydrolyzing metal salts, Advances in Colloid and Interface Science, 100: 475-502.

Exall, K. and G. Vanloon, 2000. Using coagulants to remove organic matter. *Journal AWWA*. November 2000.

Gregor, J., C. Noke and E. Fenton, 1997. Optimizing natural organic matter removal from low turbidity waters by controlled pH adjustment of aluminium coagulation. Water Research, 31(22): 2249-2958.

Heimer, I.H., 2004. Kirk-Othmer encyclopedia of chemical technology. John Wiley & Sons. New York, 11: 488-517.

Huang, C. and H. Shiu, 1996. Interaction between alum and organics in coagulation, Colloids and Surfaces A: Physicochemical and Engineering Aspects, 113: 155-163.

Kent, D.K., 1992. Water treatment plant operation, 1(4). Coagulation and flocculation, California State University, Sacramento. School of engineering. USA.

Lamer, V.K. and T.W. Healy, 1963. Adsorbsion-flocculation reaction of micromulecules at the solid-liquid interface. Rev. Pur App. Chem., 13: 112-132.

Larsson, A., C. Walldal and S. Wall, 1999. Flocculation of Cationic polymers and nanosized particles, Colloids and Surfaces., 159: 65-76.

Ming-yan, S.H. and S. Shou-zhi, 2002. Optimization of coagulants in the treatment of polluted water with low temperature and turbidity. World congress of soil science, 2002, China.

Montogomery, J.M., 1995. Water treatment principles and design. John Wiley and Sons Inc. USA.

Omoike, A. and G. Vanloon, 1999. Removal of phosphorus and organic matter removal by alumduring wastewater treatment. Water Res., 33(17): 3617-3629.

Rebhum, M. and M. Lurie, 1993. Control of organic matter by coagulation and floc separation. Water Sci. Tech., 27(11): 1-20.

Shahmansouri, M.R. and A.A. Neshat, 2003. Comparison of PAC, Alum and Ferric chloride in removal of TOC and total coli form. Water and wastewater, 48: 39-44.

Standard Methods for the Examination of Water and Wastewater, 1998. 20^{th} ed., American Public Health Association/AWWA, Washington DC, USA.GEORGANTAS *et al*., 130.

Svetlozar, V., G.C. Joao and A.R. Maria, 2004. Removal of inorganic anions from drinking water supplies by membrane bio/processes. *Rev.* Environ. Sci. Biotech., 3(4): 361-380.