Available online at www.scientiaresearchlibrary.com

Scientia Research Library

ISSN 2348-0408
USA CODEN: JACOGN

Journal of Applied Chemistry, 2014, 2 (1):82-91
(*http://www.scientiaresearchlibrary.com/arhcive.php*)

Comparatively Study of Polymer and Regular Coagulant for Municipal Waste Water Treatment

Ronak Desai[1] ,Omprakash Sahu[2]
Department of Chemical Engg., KIT, KIT, Jamnagar (Gujarat), India

---

ABSTARCT

A polymer-based coagulant and flocculent agent was tested in this study in order to treat urban wastewater. Polymer-based coagulant and flocculent agent has showed a high effectiveness in turbidity removal (almost 100%, depending on the dosage) and around 50% of BOD_5 *and COD removal, which makes polymer-based coagulant and flocculent agent an appropriate coagulant agent with efficiency that is comparable to alum's. Coagulant and flocculent process does not depend on temperature, and optimum agitation speed and time have been found to be 40 rpm for 30 min. Polyphenol content does not increase drastically, and 30% of anionic surfactants are removed. Sedimentation process seems to be a flocculent separation so Sludge Volumetric Index and its evolution with flocculent dosage have been determined. Polymer-based coagulant and flocculent agent has been revealed as a quite effective coagulant and flocculent agent in wastewater treatment.*

Keywords: BOD; COD, Coagulant; Flocculent; Turbidity

INTRODUCTION

In wastewater treatment operations, the process of coagulation and flocculation are employed to separate suspended solids from water. Finely dispersed solids (colloids) suspended in wastewaters are stabilized by negative electric charges on their surfaces, causing them to repel each other. Since this prevents these charged particles from colliding to form larger masses, called flocs, they do not settle. To assist in the removal of colloidal particles from suspension, chemical coagulation and flocculation are required [1]. These processes, usually done in sequence, are a combination of physical and chemical procedures. Chemicals are mixed with wastewater to promote the aggregation of the suspended solids into particles large enough to settle or be removed [2]. Coagulation is a well-known process which purpose, combined with a solid-liquid separation process, is the removal of turbidity, colour or micro-organisms that are present in the wastewaters as colloidal suspensions. These suspensions are a heterogeneous mixture of particles with different size, shape and chemical composition. A colloid has been defined as a dispersion of distinguishable particles in the size range of 0.01–10 mm in a medium that may be regarded as a structure less continuum [3, 4]. Colloidal systems will usually scatter light, that is, they exhibit turbidity, which is related to the sizes of the particles involved. Colloidal suspensions in aqueous media appear cloudy, and the observed turbidity depends on both the particle size distribution and the mass concentration present. This type of particles tends to remain in suspension for a long period of time and due to its great stability colloids do not form aggregates [5-9]. The most important interactions affecting suspension stability are electrostatic repulsion and Van der Waals attraction. These two interactions are assumed to be additive and together establishing the total energy of interaction between particles as a function of separation distance. Attraction predominates at short distances and repulsion is more effective at greater distances [10]. To eliminate these particles the electrostatic forces of the suspension must be destabilized. Then if there is enough kinetic energy available a separation distance can be reached where attraction becomes more effective and particle collision and aggregation can occur [11].

Coagulation can be described as the agent induced aggregation of particles suspended in liquid media into larger particles. The coagulation favours, with the help of slow stirring, the contacts between the destabilized particles. The particles aggregate to form flocs that are more easily removed. The four mechanisms of coagulation are recognised: compression of the diffuse layer, adsorption to produce charge neutralization, enmeshment in a precipitate and adsorption to permit antiparticle bridging [12]. The destabilisation of colloids in water and wastewater is probably accomplished by adsorption of oppositely charged soluble and insoluble coagulant hydrolysis species on the colloid and subsequent destabilisation, enmeshment of colloid within hydroxide or carbonate precipitates, or both.

Flocculation is the action of polymers to form bridges between the flocs and bind the particles into large agglomerates or clumps [13, 14]. Bridging occurs when segments of the polymer chain adsorb on different particles and help particles aggregate. An anionic flocculent will react against a positively charged suspension, adsorbing on the particles and causing destabilization either by bridging or charge neutralization. Once suspended particles are flocculated into larger particles, they can usually be removed from the liquid by sedimentation, provided that a sufficient density difference exists between the suspended matter and the liquid. Summarising, coagulation-flocculation process consists of three steps: coagulation of the suspended solids, growing of the microflocs and elimination of the floc aggregates formed [15]. Besides the wastewater composition the process is strongly influenced by kinetics process parameters such as rapid and slow mixing steps. The initial phase of the coagulation process is the rapid mixing. The coagulant species causing destabilisation are transported by turbulent eddies which interact with the particles in the fluid by collisions [16]. The rapid mixing step is then followed by a period of less intense agitation where floc growth takes place up to sizes suitable for removal. Coagulants play an important role in the treatment of water and wastewater and in the treatment and disposal of sludge. Aluminium sulphate, alum, is the common chemical coagulant used in the coagulation process. Recently polymers have been utilized in coagulation/flocculation processes for water purification [17]. Polymers have been utilized in coagulation/flocculation processes for water purification for more than three decades. Organic polymers may be used as primary coagulants as well as in the more traditional flocculation step of binding already formed small flocs into larger particles in drinking water treatment. Coagulation with organic polymers followed by sedimentation can clean up industrial effluent when the flocs formed are dense enough [18]. A major use of organic polymers in water treatment is as a coagulant aid to bridge the coagulated particles formed when aluminium or iron salts have been used as the primary coagulant. The large aggregates formed then settle more rapidly. The main advantages of natural polyelectrolytes are ready acceptance on health grounds and ease of biodegradation. Polymers have already received attention.

For several years, investigators are concerned towards cooperation among developing countries and they are working on an alternative process for water treatment, mostly bearing in mind concepts such as sustainability, affordability and social feasibility. In this sense, natural coagulants/flocculants are wide-spread, easy-handling resources that are not difficult to work with by non-qualified personnel. Polymers may be a new source for coagulant and flocculant agents. The study conducted to uses a new polymer-based coagulant and flocculant agent (CHINTOS) for treating urban wastewater [19]. The characterized polymers obtained from valonia, an autochthonous tree from Turkey, and used them for coagulation– flocculation process of wastewater. The authors demonstrated that polymer has a very good effect, combined with $Al_2(SO_4)_3$ in order to enhance further stages of sludge removal [20]. The main objective of the study is to evaluate the new polymer coagulant for the treatment of municipal waste water.

MATERIALS AND METHODS

Reagents

CHINTOS was supplied by Merk Chemical Ltd and Alum ($Al_2(SO_4)_3.18H_2O$) has been supplied by SIGMA Co Ltd.

Raw water

Raw water was obtained from the Wastewater Treatment Plant. It receives municipal wastewater from 4000 people. The effluent has a moderately low COD charge. Average incoming flow rate is41.63 m^3/h. Water involved in this study was collected after previous big solids separation and before oil and sand separation [21]. The main physico-chemical characteristics of this water are shown in the Table 1 given below.

Table1: Municipal waste water parameter

S.No	Parameter	Value	Units
1	Turbidity	82.5	NTU
2	Suspended solids	100	Ppm
3	Total solids	650	Ppm
4	Anionic surfactants	3.9	Ppm
5	Polyphenols	6.4	Tannic acid equivalent ppm
6	KMNO4 oxidability	65.6	O_2 ppm
7	BOD	130	O_2 ppm
8	COD	210	O_2 ppm
9	Chloride	21.3	Cl^- ppm
10	Calcium	94.6	Ca^{2+} ppm
11	Hardness	444	$CaCO_3$ ppm
12	Conductivity	1006	$\mu S\ cm^{-1}$
13	Nitrate	22.5	NO_3^- ppm
14	Nitrite	0.04	N ppm
15	Ammonium	2.1	N ppm
16	Phosphate	7.3	P ppm
17	Total phosphrous	11.9	P ppm
18	pH	8.2	

Jar-test procedure

Jar-test was selected as the standard treatment in order to study flocculant process. The procedure was: 0.5 L of turbidity-known wastewater was put into a beaker. Certain dose of flocculant was added, and beaker was put into a Jar-test apparatus [22]. Two stirring periods were applied: one at 100 rpm for 2 min and another one at a lower speed for a longer period. In order to study the influence of this last period, its duration and agitation intensity were varied. Turbidity was measured by a turbid meter 1 h after Jar-test was finished. Turbidity sample was obtained from the center of the beaker, 3 cm from the surface.

Analytical methods

Analytical measures were made according to the American Public Health Association standard methods. Measures referring sludge production and Sludge Volumetric Index (SVI) were done with a 25-mL calibrated test tube and 1-L Imhoff cone. In the first case, a 25-mL sample was collected just after coagulation and flocculation process (without sedimentation) and suspended solids were determined by millipore fine filtration (45 μm glass fibre filter). In the second case, Imhoff cone received a 0.5-L sample of treated water and it was allowed to settle for 1 h. Then, sludge volume was measured as Imhoff cone was calibrated. Anionic surfactants were determined by a method based on methylene blue-anionic surfactant association. 10 mL of clarified sample was put into a separation funnel. 25 mL of trichloromethane and 25 mL of methylene blue solution were added and the funnel was shaken vigorously. Organic fraction was taken out and put into another separation funnel, in which 50 mL of cleaning solution was added. Funnel was shaken again, and the resultant organic fraction was put into a 25-mL flask. It was filled up to the mark with trichloromethane and surfactant concentration was determined by visible spectrophotometry at 625 nm, with zero made with pure trichloromethane by using a spectrophotometer [23-25].

RESULT AND DISSCUSION

Comparison between CHINTOS and alum effectiveness

Raw water was treated with 100 ppm of each product in a standard Jar-test procedure, which consisted of 100 rpm for 2 min and 30 rpm for 20 min, 1-hour settling and samples was collected from the supernatant clear surface. Both products have demonstrated a high level in clarifying, almost the same in turbidity removal, COD and BOD_5. In the case of $KMnO_4$ oxidability (another measure of organic matter) CHINTOS has revealed a very slight enhancement compared with alum. The results are shown in figure.1 given below.

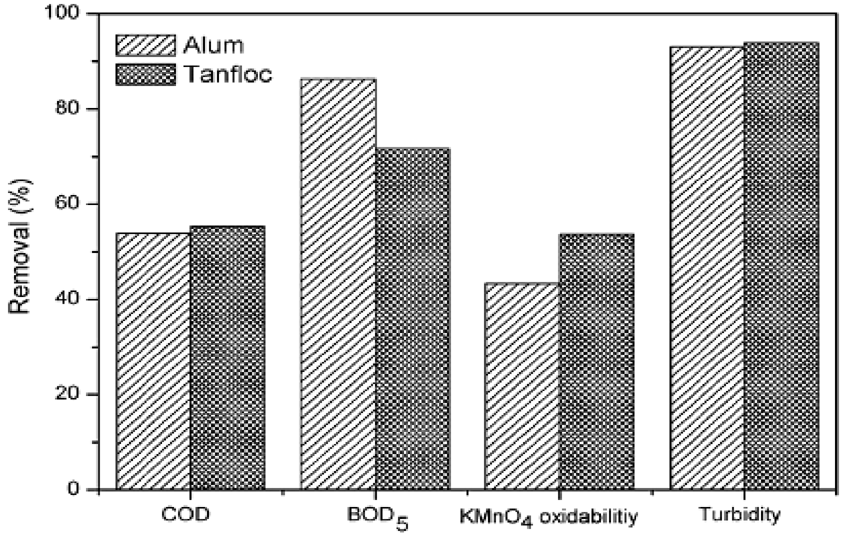

Fig.1: Effectiveness comparison between CHINTOS and alum

Effect of Jar Test parameter

Agitation speed

Agitation speed was varied between 10 and 50 rpm for a fixed period of 10 min. Turbidity removal results are shown in figure. 2. Turbidity removal varied between 80 and 90%. It kept rather constant, but a slight improvement was observed when agitation speed was increased from 30 to 40 rpm. Stirring speed is important from the point of view of helping flocs to be formed so 40 rpm value was selected as optimum one.

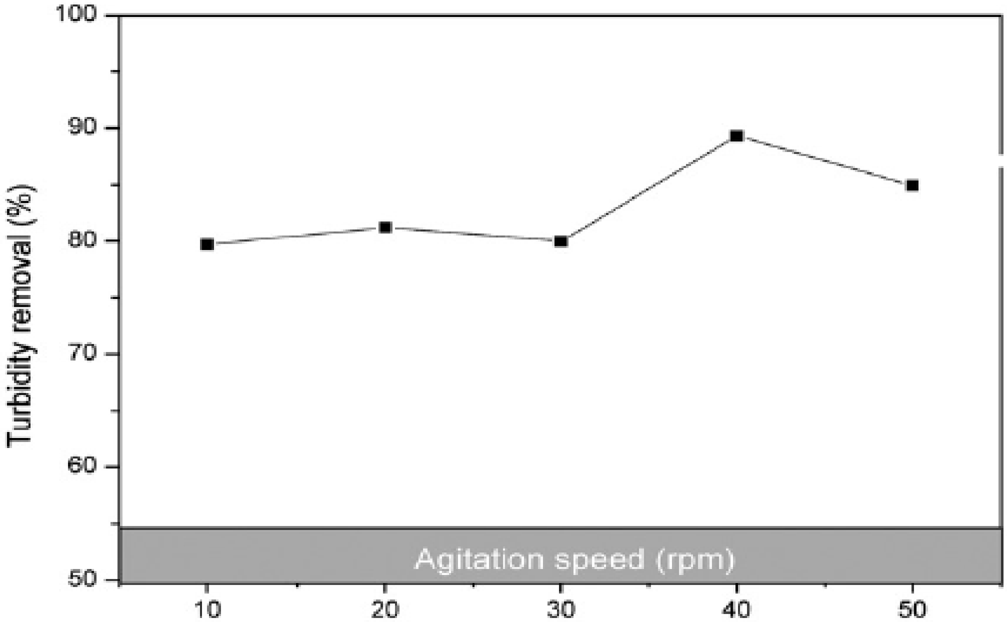

Fig.2: Influence of agitation speed on turbidity removal

Agitation time

Agitation time was varied from 5 to 30 min. Figure.3 shows an almost linear variation of effectiveness in turbidity removal. Turbidity removal varied between 80 and 90%. 30 min was selected as an average value in order to complete the Jar-test procedure that would be used in the whole investigation: 100 rpm, 2 min plus 40 rpm, 30 min.

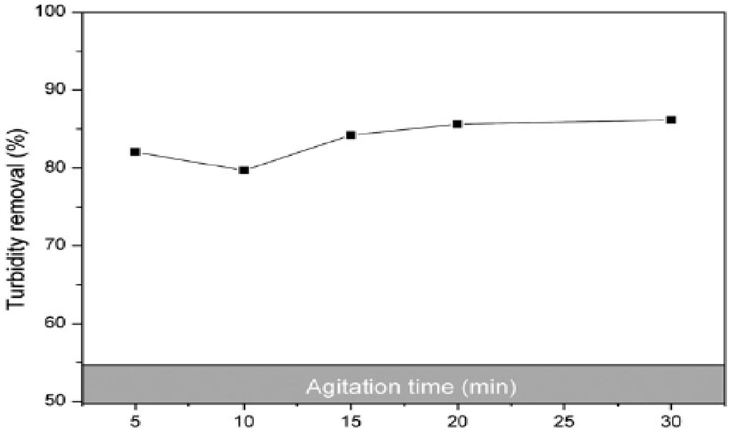

Fig.3: Influence of agitation time on turbidity removal

Temperature influence

Temperature has been evaluated as a factor in the coagulation/flocculation process to account for seasonal variation. Temperature is also important in order to extrapolate the present results to other similar effluents, such as industrial ones, which may come into the treatment plant with very different conditions. As shown in Figure.4, temperature does not affect the effectiveness of the process. By varying temperature from 10 to 40 ºC no enhancement or worsening in turbidity removal was observed. Hence, CHINTOS may be an effective coagulant/flocculent agent even in the case of thermal-contaminated waters.

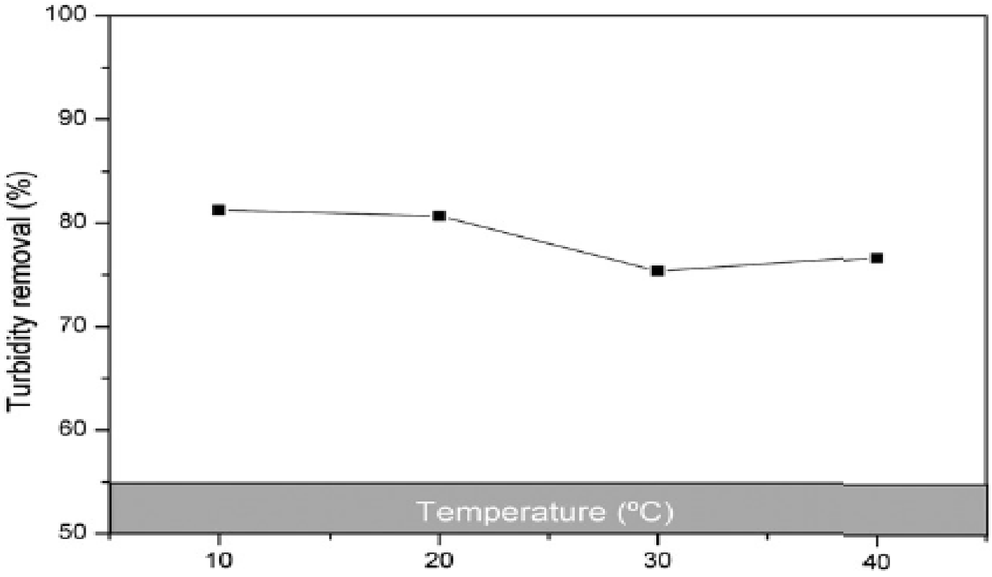

Fig.4: influence of temperature on turbidity removal

Operating parameters and treated water quality
Dosage influence

Flocculent dosage has been varied between 0 and 150 ppm. Turbidity removal increased quite quickly with flocculent dosage. 80%-effectiveness was achieved with 40 ppm of CHINTOS. Almost a total turbidity removal appears with dosages around100 ppm. This is illustrated in the figure.5 given below.

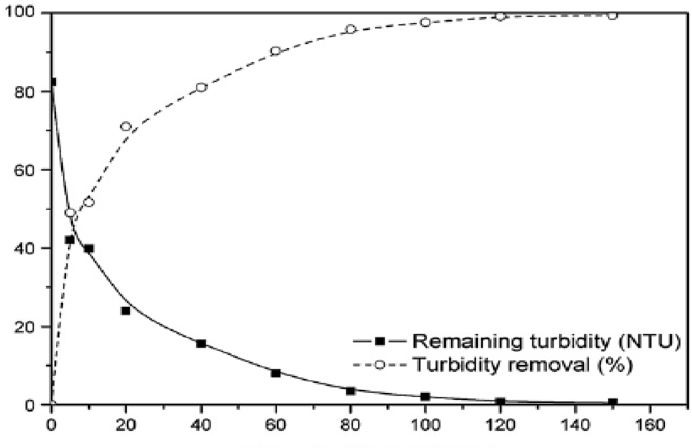

Fig.5: general turbidity removal evolution with flocculent dosage

Sludge production and suspended solids removal

Sludge production is an important task in order to evaluate efficiency in coagulation/flocculation process. It may be as low as possible, and sludge volume may be reduced as well. In the case of CHINTOS, sludge production, sludge volume and the relationship between these two parameters, which is called Sludge Volumetric Index (SVI), was determined. SVI is defined by Eq. (1):

$$SVI = Vs/Ws \qquad (1)$$

Where,

Vs = volume that is occupied by the sludge (mL) and;

Ws = sludge mass (g)

From figure.6 it could be seen that the three magnitudes were increased as flocculent dosage became higher. Suspended solids and sludge volume were increasing which had a less steep slope than SVI. From 80 ppm and ahead, flocculation capacity of CHINTOS seemed to be less efficient, and a sludge compression seemed to appear as SVI decreased. This fact was rather normal in sedimentation process.

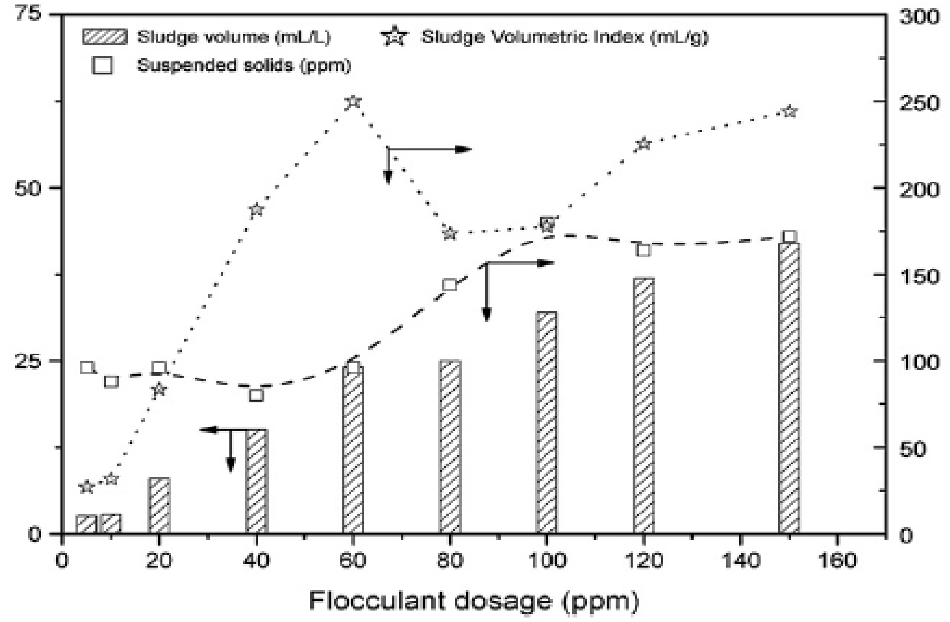

Fig.6: sludge production and suspended solids removal with flocculent dosage

Anionic surfactant and polyphenol removal

Anionic surfactants: Surfactant dumping into environment represents a harmful and noxious practice. They may be useful and needed compounds, but they are also considered dangerous and non-desirable substances because of their impact on water animal and vegetal life. The main aspects in which surfactants modify on environmental equilibrium involve groundwater and lakes pollution, pharmaceutical product binding (so pollution activity of these kinds of chemical compounds is considerably increased), animal and human toxicity and biopersistance. These are the main reasons why anionic surfactant removal by this polymer-based flocculant was evaluated. As it could be seen in figure.7, CHINTOS removed almost 30% of anionic surfactants, due to surfactant-turbidity adsorption and further turbidity removal. This removal tends to be constant since 60–80 CHINTOS ppm dosage and ahead, as no improvement was observed with the highest dosages.

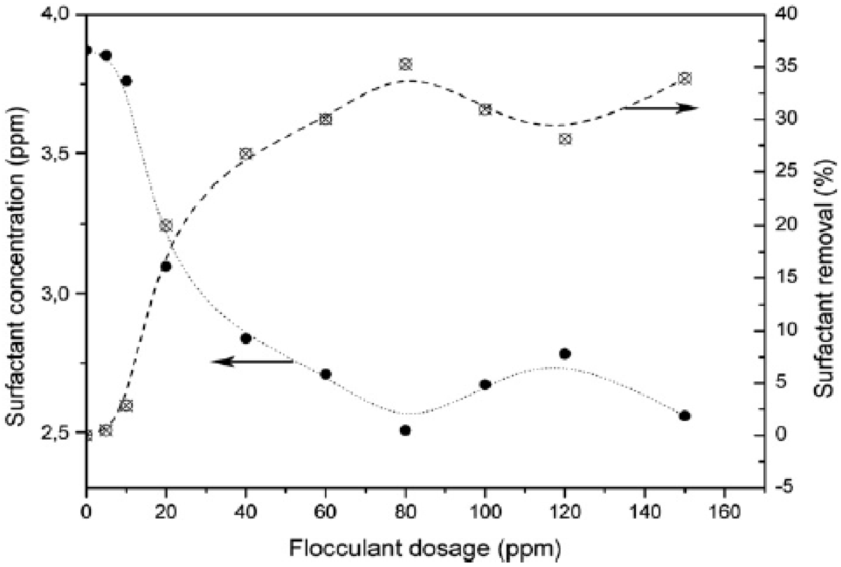

Fig.7: Surfactant removal assay

Polyphenols: Figure.8 shows residual polyphenol level in water. It was kept reasonably constant, or with a very slight decreasing, until 60 ppm CHINTOS dosage was reached. From then and above, polymer content began to increase. This was surely due to the fact that efficiency of CHINTOS became lower since this point, so a fraction of flocculent remains in water without being removed by flocculation.

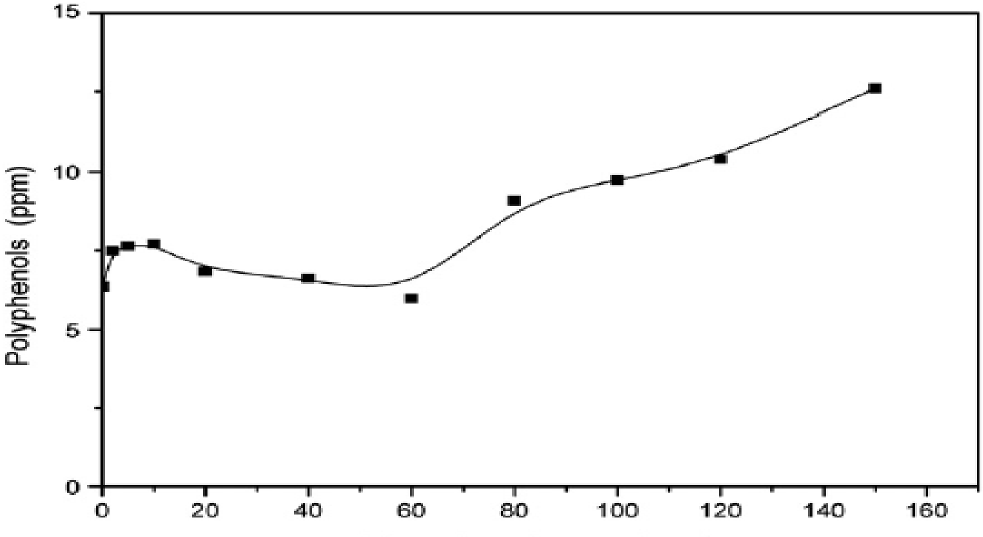

Fig.8: Residual polyphenol assay

Organic matter removal

As shown in Table 1, not so high levels of organic matter are found in raw water (210 and 130 O_2 ppm for COD and BOD_5 respectively). However, a quite decrease in both parameters was achieved with a reasonably low flocculant dosage. Figure.9 shows a maximum COD removal around 60CHINTOS ppm; and a maximum BOD_5 removal around 20CHINTOS ppm. Biodegradability (understood as the relationship between COD and BOD5) was rather constant and comprised inside the range of 0.5–0.7, which represents a quite high value if compared with other types of wastewater.

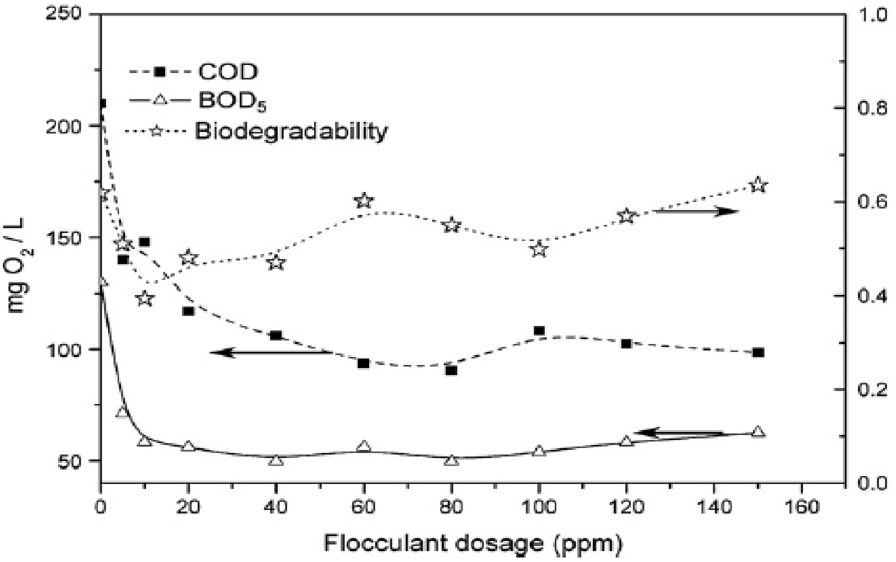

Fig.9: COD, BOD_5 and biodegradability evolution with flocculent treatment

CONCLUSION

Effectiveness of CHINTOS is comparable in all senses with alum ability for removing BOD_5, COD and turbidity. Up to 80% of turbidity removal is achieved with around 40 ppm of CHINTOS, so low dosages of flocculants are quite effective in water treatment. Sludge production is reasonably within normal ranges, and presents no aluminium or iron salts disadvantages. Up to 30% of anionic surfactant is removed with CHINTOS treatment, and no excessive polyphenol content is observed in treated water. A reasonably COD and BOD_5 reduction is obtained by CHINTOS treatment. Water biodegradability may be found to be in the range of 0.5–0.7.

REFERENCES

[1]. M.L. Wolfrom, D.N. Kolb, A.W. Langer, Chemical interactions of amino compounds and sugars. VII, pH dependency, J. Am. Chem. Soc. 75 (**1953**) 3471–3473.

[2]. M. Pe˜na, G. González, N. San, C. Heras, Color elimination frommolasses wastewater by Aspergillus niger, Bioresour. Technol. 57 (**1996**) 229–235.

[3]. M. Coca, M. Pe˜na, G. González, Variables affecting efficiency of molasses fermentation wastewater ozonation, Chemosphere 60 (**2005**) 1408–1415.

[4]. S.H. Mutlua, U. Yetisb, T. Gurkana, L. Yilmaza, Decolorization of wastewater of a baker's yeast plant by membrane processes, Water Res. 36 (**2002**) 609–616.

[5]. M. Pe˜na, M. Coca, G. González, R. Rioja, M.T. García, Chemical oxidation of wastewater from molasses fermentation with ozone, Chemosphere 51 (**2003**) 893–900.

[7]. A. Pala, G. Erden, Decolorization of a baker's yeast industry effluent by Fenton oxidation, J. Hazard. Mater. B127 (**2005**) 141–148.

[8]. M. Goto, T. Nada, A. Ogata, A. Kodama, T. Hirrose, Supercritical water oxidation for the destruction of municipal excess sludge and alcohol distillery wastewater of molasses, J. Supercrit. Fluid. 13 (**1998**) 277-282.

[9]. Ikuko, T. Yukiko, O. Sadahiro, U. Kiyimoto, Production of decolorizing activityfor molasses pigment by Coriolus versicolor Ps4a, Biol. Chem. 49 (**1985**) 2041–2045.

[10].K.F. Fannin, J.R. Conrad, V.J. Srivastava, D.P. Chynoweth, D.E. Jerger, Anaerobic treatment of winery wastewater, J. Water Pollut. Control Fed. 59 (**1987**) 403–410.

[11]. S.C. Jones, F. Sotiropoulos, A. Amirtharajah, Numerical modeling of helical static mixers for water treatment, J. Environ. Eng. ASCE 128 (**2002**) 431–440.
[12]. W. Zhao, Y.P. Ting, J.P. Chen, C.H. Xing, S.Q. Shi, Advanced primary treatment of wastewater using a bio-flocculation–adsorption sedimentation process, Acta Biotechnol. 20 (**2000**) 53–64.
[13]. Y.X.Wang, Z. Liang, X.M. Yuan, Y.S. Xu, Preparation of cellular iron usingwastes and its application in dyeing wastewater treatment, J. Porous Mater. 12 (**2005**) 225–232.
[14]. V. Migo, M. Matsumura, E.J. Rosario, H. Kataoka, Decolorization of molasses wastewater using an inorganic floculant, J. Fermentation Bioeng. 75 (**1993**) 438–442.
[15]. D. Ryan, A. Gadd, J. Kavanagh, M. Zhou, G. Barton, A comparison of coagulant dosing options for the remediation of molasses process water, Sep. Purif. Technol. 58 (**2008**) 347–352.
[16]. APHA, Standard Methods for the Examination of Water and Wastewater, 19th edition, American Public Health Organization, Washington, DC, USA, **1995**.
[17]. A. Amokrane, C. Comel, J. Veron, Landfill leachates pretreatment by coagulation–flocculation,Water Res. 31 (**1997**) 2775–2782.
[18]. E. Lefebvre, B. Legube, Iron (III) coagulation of humic substances extracted from surface waters: effect of pH and humic substances concentration, Water Res. 24 (**1990**) 591–606.
[19]. K.G. Nierop, B. Jansen, J.M. Verstraten, Dissolved organic matter, aluminium and iron interactions: precipitation induced by metal/carbon ratio, pH an competition, Sci. Total Environ. 300 (**2002**) 201–211.
[20]. A. Matilainen, N. Lindqvist, S. Korhonen, T. Tuhkanen, Removal of NOM in the different stages of the water treatment process, Environ. Int. 28 (**2002**) 457–465.
[21]. J. Manka, M. Rebhum, Organic groups and molecular weight distribution in tertiary effluents and renovated waters,Water Res. 16 (**1982**) 399–403.
[22]. R.L. Sinsabaugh, R.C. Hoehn, W.R. Knocke, A.E. Linkins, Removal of dissolved organic carbon by coagulation with iron sulfate, J. Am. Water Works Assoc. 78 (**1986**) 74–82.
[23]. M.I. Aguilar, J. Sáez, M. Lloréns, A. Soler, J.F. Ortu˜no, V. Meseguer, A. Fuentes, Improvement of coagulation–flocculation process using anionic polyacrylamide as coagulant aid, Chemosphere 58 (**2005**) 47–56.
[24]. J. Duan, J. Gregory, Coagulation by hydrolysingmetal salts, Adv. Colloid Interface 100–102 (**2003**) 475–502.
[25]E.S. Hall, R.F. Packham, Coagulation of organic color with hydrolyzing coagulants, J. Am.WaterWorks Assoc. 57 (**1965**) 1149–1163.