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Survey of clarifier' s recycled sludge effect on turbidity and coliform removal efficiency by poly aluminum chloride (PACL) in hormozgan water treatment plant

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ABSTRACT

In water treatment plants the finding of ways that meanwhile effective efficiency decreasing the coagulant substances consumption, has a great importance and is considered to engineering economy consideration. This applicable analytical study was conducted in lab scale of hormozgan water treatment by jar test on 108 samles. To choice of (PACL, recycled sludge, PACL plus recycled sludge) for turbidity removal, an examination was done at different sludge volume (from 5 to 45ml/L) and different turbidities (from 11to 98 NTU). At the end of any jar test, with the counting of samples, s remained turbidity and coliform the efficiency of this factors elimination was determined by covariance and Duncan analysis (P_{value}< %1). Results showed that the maximum turbidity and coliform removal efficiency were recovered to 97.12% and 91.35% respectively, that was obtained at 10ppm PACL plus 10ml/L recycled sludge, but optimum dose was Pertinent to 8ppm PACL plus 10ml/L recycled sludge with PH 7.5 that of efficiencies, resulted 96.81% and 91.23%, also do not significant difference between this two doses. By using the optimal dose of recycled settled sludge in this treatment plant, %20 reduction of PACL consumption was obtained equivalent to 192.3 kg per day as parsimony that is remarkable.

Key words: Hormozgan, Iran, recycled sludge, PACL, optimum dose

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INTRODUCTION

Promotion of any society dependent to considerations of engineering economy, for example in water treatment the finding of ways that along the effective efficiency, decrease the coagulant consumption for purvey of drinking waters, is conducted us to this purpose. Therefore water treatment involves science, engineering, business, and art [1]. At other side accession of healthy phenomenon such as Alzheimer coming according to inordinate aluminum consumption has caused to more sensitivity and processional control is made on water treatment process. Flocculation and Coagulation are process and operational unites in surface waters. During the coagulation process are used different coagulant and aid coagulant materials. The coagulants inclusive materials that are used for instability and stick of turbidity consist of suspended and colloidal solids of water. while the purpose of adding coagulant aids is increasing the density of adhesive particles and helping to rapid sedimentation [2].In normally the metallic salts such as Alum and Poly Aluminum Chloride, ferrous sulfate, ferric sulfate and ferric chloride is used as

coagulant and some substances such as sodium aluminate, bentunit, sodium silicate and cationic, anionic, and nonionic poly electrolytes is used as aid coagulant in water treatment process for remove turbidity [2, 3]. Generally in coagulation process the conditions must be provided to conclusion of adsorption and charge inactivity that by the return sludge to prime of flocculation process, this condition is found. On the other hand, aluminum is still some left in the sludge so it can be used. Sludge was predicted by coagulation process containing complexes of aluminum that they cores can suitable agents for new floes that are heavier and can needed less time for situation. [3, 4] PACL with low concentration in aqueous field make the poly core complex and this property is the unique ability for coagulant process. This matter has polymeric structure with formula of $\left(Al_3(OH)_{b-X}Cl_x.YH_2O\right)_Z$ which is produced by chemical reaction between Aluminum Hydroxide and Chloridric acid according to $2Al(OH)_3 + nHCL \rightarrow Al_2(OH)_nCl_{6-n} + H_2O$ [4, 5]. In Poly Aluminum Chloride molecules, Aluminum there is as polymer consist of Hydroxide and Chloridric factors, and in some cases consist of mineral salts such Sodium and Chloride. Against the Alum that small part of it appears to monomeric forms, in Poly Aluminum Chloride molecule more proportion of Aluminum appears to great Alligomer polymers to $[Al_{13}(OH)_{24}O_4(H_2O)]^{17}$ figure [5-8]. Some of the PACL' s advantages include: That coagulation efficacy is from 2 to3 time higher than ordinary Aluminum salts. Flock formation occurs rapidly so short time needed for reaction and sedimentation, by using the similar dose of coagulants, reduction of PH after the PACL consumption is lesser than other mineral coagulants, Specially for treatment of very turbid waters short time needed to set the PH of treated water, lesser sensitivity to temperature ,leave less residue than other metallic coagulants , reduction of produced sludge and facility of dewatering, are factors that increased the PACL consumption for water treatment [7]. This study was implemented to target of determine the optimum performance condition of PACL with recycled sludge and scrutiny of their turbidity removal efficiency in hormozgan water treatment Plant. Research of Akbar Baghvand showed that highest turbidity removal efficiency of Alum were recovered from 82.9% to 99.1% and of ferric chloride was from 92.9% to 99.4% over the applied range of turbidity [9]. In study of Binna's to comparison of Maringa oulifra seed and PACL for remove of water turbidity showed that optimum dosage of PACL to removal of about 50 NTU turbidity was 20 ppm at PH 7.5 that finally come down to 2.5 NTU, and so it is able to remove 95% turbidity [10]. To compare of turbidity reduction efficiency a 12.5 ml dose of *M. oleifera* is equivalent to 4 ml dose of Alum and 5.4 ml dose of PACL [11]. The aim of this study are Survey of clarifier, s recycled sludge effect on Turbidity and Coliform removal efficiency by Poly Aluminum Chloride (PACL) in Hormozgan water treatment plant**.**

MATERIALS AND METHODS

Site description

This study was performed in lab scale by JLT6 model of Jat test system in Hormozgan water treatment plant (figure 1).

Field measurements

According to local climate conditions and records of row water turbidity, sampling was done in winter season from inlet row water and totally was taken108 samples to range from 10 to 100 NTU. Before addition the coagulants firstly was measured Turbidity, Temperature, Alkalify and pH according to standard methods 2005 guideline [12]. In during jartests the rapid mix was regulated to 120 rpm at one minute and then slow mix on 30rpm at 10 minutes, 20rpm at 10minutes, 10rpm at 10minutes respectively. After this stages samples rested for settlation to 30minutes.Then sampling was done for examination from 5cm of basher's surface below. Then four stages were performed to this discretion:

1. PH was slated to range of from 5 to 8 by 1% normal of Sodium Hydroxide, then by addition seven dose of PACL, optimized PH was determined equal7.5
2. doses of PACL (from 5 to 35ppm) was added to optimized PH until be achieved optimum doses of PACL
3. Resulted dose of PACL was as base for next analysis and this time jartest was done by lesser doses of PACL plus different doses of sludge, then effect amount of recycled sludge was determined. During one of the sludge concentrations optimized doses of PACL has been reduced to its minimum volume, so this brings as optimized favorite dose of PACL.
4. Jat tests was performed at different turbidities by added selective optimal doses of PACL plus different doses of sludge, until finally research be done for categorize of Turbidity and Coliform, removal efficiency and selection of best dose of PACL plus sludge and determine significant between variants by Covariance and Duncan analysis.(p_{valu}<1%)

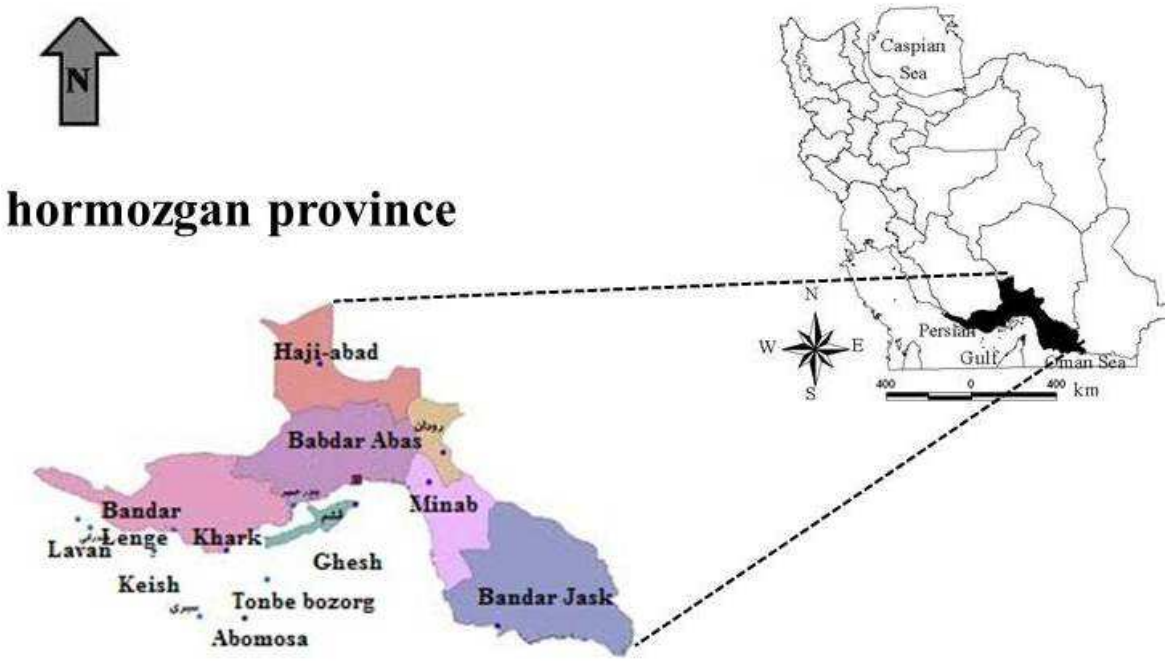

Figure 1. Study site location in the Hormozgan Province, southern Iranian state of Iran

RESULTS AND DISCUSSION

*A): **Determination of optimal doses of PACL plus recycled settled sludge***

When fixed concentrations of PACL were added on six samples containing different turbidity and their PH were sated on 5-8 , jar tests showed that most turbidity removal was occurred at 7.5 PH, so at next stages of research all samples was regulated on this optimum PH. At the first phase of jar tested by injection different doses of PACL on 8 samples containing different turbidities, doses of 10 and 25ppm which had most turbidity removal efficiency were chosen as basic number. Then jar tests was done by its lesser doses of PACL (10, 9, 8,7,6,5 ppm) plus nine doses (5 to 45 ml/L) of sludge which in this stage were taken from clarifier' s discharge pipe. In this stage 9 tests at any turbidity and totally 90 jar tests were done. Finally dose of 8ppm that had more repeat in jar tests results was defined as optimum dose with the added sludge. According to write restriction the finally results was mentioned in (1.3) table.

Table 1: optimum doses of PACL for different turbidities and doses of sludge

optimum doses of PACL plus sludge												
optimum doses of PACL (mg/l)	Sludg (ml/L)										turbidity Remo	sample group
	45	40	35	30	25	20	15	10	5	0	45	
9	10	10	9	8	9	10	®9	9	9	10	12	1
8	9	9	8	7	8	®8	® 8	8	9	10	11	2
8	10	9	8	8	7	9	® 8	9	10	10	64	3
8	9	10	10	8	7	8	® 8	9	9	10	32	4
7	9	10	9	8	® 7	8	9	9	10	10	98	5
9	8	8	9	8	9	9	®9	10	10	10	98	6
8	9	9	8	7	7	® 8	10	9	10	10	57	7
8	10	9	8	10	9	8	®8	9	10	10	35	8
10	10	9	8	7	9	10	10	10	10	®10	11	9
8	10	9	9	10	9	8	® 8	9	9	10	42	10

In table

1 mark ®means the optimum doses of recycled sludge which in any turbidity had the most efficiency of PACL reduction during the coagulation process. This table resulted imprimis: most of favorable cases of coagulation occurred in 10ml/L sludge injected on different doses of PACL, also in more volumes the effect of Turbidity removal is reduced and increase in turbidity is, However lower than input amount .The result is to selection the10ml/L of sludge as optimal dose, and in this trend there is significant relevancy between optimum dose of added sludge and effluent turbidity. Secondary result is that 8ppm dose of PACL which has most rapidity in reduce consumption of PACL in jartests was determined as optimized dose after sludge addition on them.

B) Survey of Turbidity and Coliform removal efficiency in optimal doses of PACL plus recycled sludge

In this stage on 12 samples containing turbidity that were ranged from 11.2 to 98.4 NTU the jar testes was done by addition different doses of sludge (5 to 45ml/L) plus mentioned PACL's optimal dose. by calculate of this stage finally108 jar tests was done .according Anova analysis in results of turbidimetry there was significant difference between volume of injected sludge and turbidity removal efficiency, and according Duncan analysis turbidity removal efficacy in cases variety of PACL plus sludge was clasificated in four classes.(P_{value}<0/01)

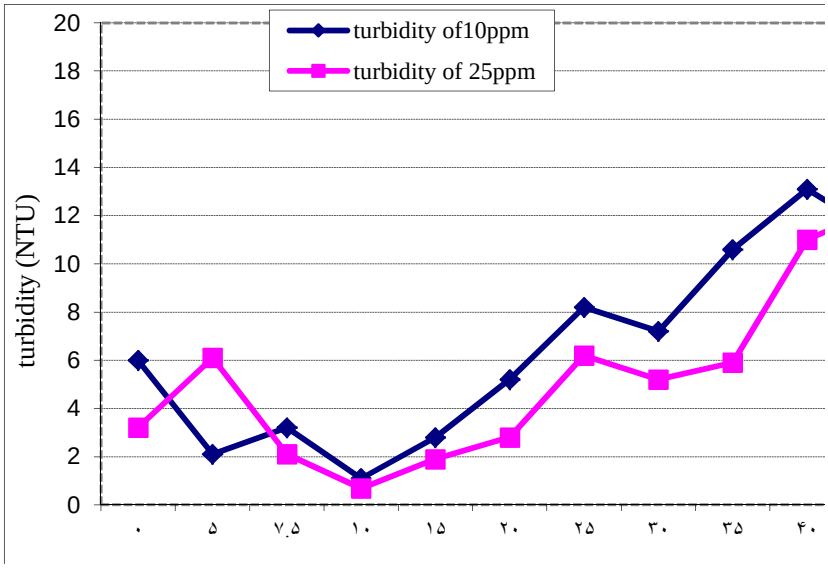

Figure 2: Effluent turbidity after addition sludge different volumes on optimized dose of PACL

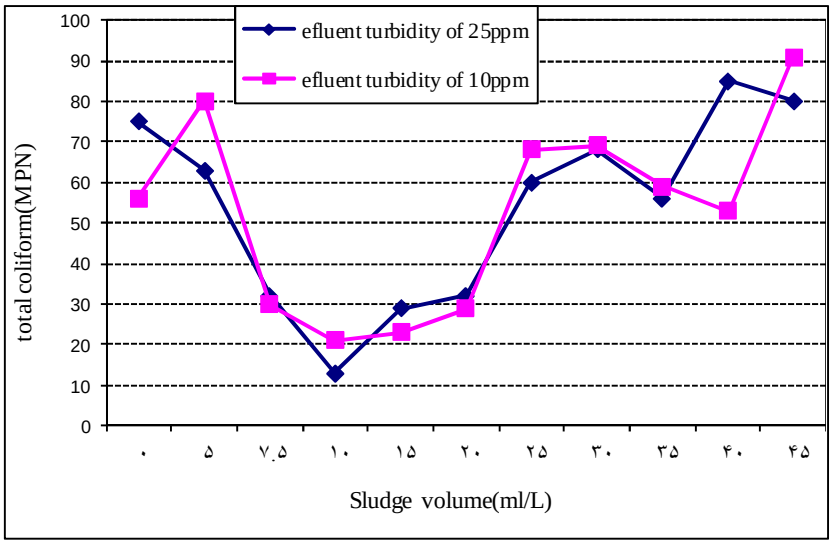

Figure3: Effluent total coliform after addition sludge different volumes on optimized dose of PACL

Doses of10ppm PACL plus 10ml/L sludge and 25ppm PACL plus 5ml/L sludge were in one group. In dose of 10ppm PACL by adding the 5 to 45ml/L of sludge , the output turbidity was to rang of 1.21 to 13.07 NTU, also in dose of 25ppm PACL by adding the similar volumes of sludge ,effluent turbidity was in rang of.79 to 12.18NTU.This times for achieving the optimum dose of sludge to saving the coagulant, turbidity and coliform

removal efficiency was investigated in modes of addition the sludge's optimal dose(10ml/L)on two dose of PACL .Turbidity and coliform removal efficiency in mode of 10ml /L sludge injection on 25ppm PACL was %97.12 and %91.35 respectively. And by addition on 10 ppm PACL was to %96.33 and %90.72 respectively. Study of Takdastan.A showed that average turbidity removal efficiency come to %98.31 which there was in 10ppm dose of PACL plus 10ml/L volume of recycled sludge, however maximum turbidity removal efficiency come to %98.92 that occurred in 30 ppm dose of PACL plus 4ml/L volume of sludge [4] In this condition Test analysis at (P_{value}<10/0)dose not show significant difference between them efficacy. So according to reduction of coagulant consumption,TOC reduction and sludge discharge 10ppm PACL plus 10ml/L sludge was determined as optimized dose until this stage, but this trend is searched more. When in order to reduction of PACL' s optimal dose to less doing jar tests, in 0 to 10ppm PACL the most efficiency of turbidity and coliform was occurred by 8ppm dose. So this optimized dose for PACL is confirmed and that turbidity and coliform removal efficiency were recovered to 96.81% and 91.23% respectively.

Survey of McLane showed that by transfusion of clarifier's recycled settled sludge on coagulant, HPC remove efficiency come to 99.2% and turbidity was reduced to 96.17%.[13]

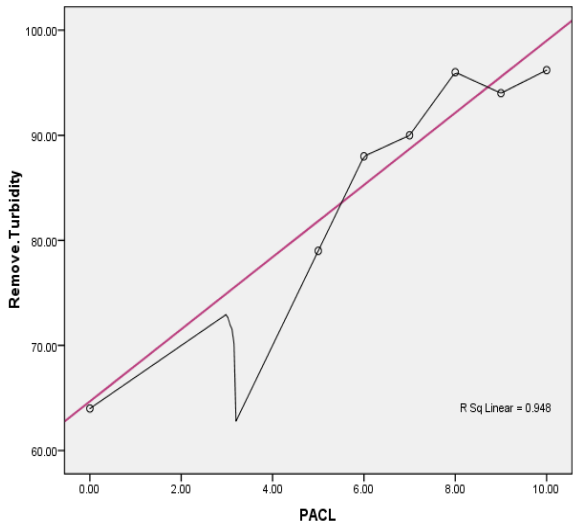

Figure 5: Turbidity removal efficacy

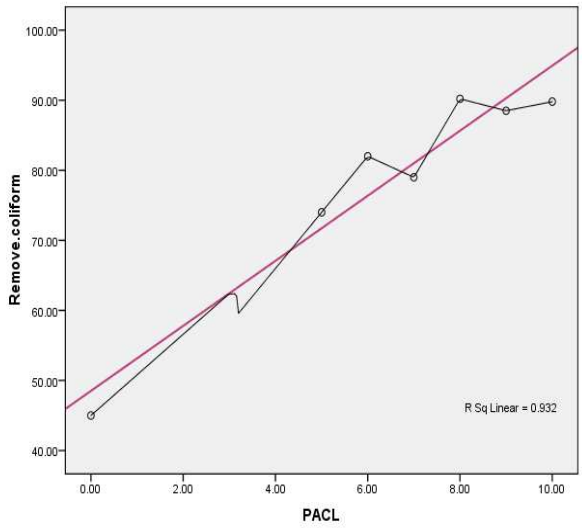

Figure 4: total coliform removal efficacy

In mentioned optimized condition, regression analysis showed there is relationship between dosage of PACL and optimum volume of sludge. Also Turbidity and Coliform removal efficiency was as linier type that (R^2) coefficient for removal of turbidity and coliform were 0.948 And 0.932 respectively. Also addition of any definite doses of sludge (5 to 45ml/L) on PACL, in compare with engrossed PACL increases the turbidity removal efficiency, and during the sludge increasing the turbidity removal is increasing. It' s Physico chemical reason, existence the aluminum complexes at sludge that cores of them can be suitable agents for heavier flocks and so new flocks are precipitated in short time. But this property in a specified range is declining, insofar that addition more than 25ml/L not only have not positive effects and technical justification, rather by increasing the final turbidity and coliform, result increasing the amount of TOC in treated water. [7] According to Anova test there was significant difference between volume of injected sludge on PACL and turbidity removal percent (P_{value}<%1). Relationship type between added sludge on optimal dose of PACL and turbidity removal is as linier (R^2=.8129), and with coliform removal efficiency is as linier (R^2=.8714). Resolutely 8ppm PACL with 10ml/L was stabilized as optimized dose. Whereas with use the dose 10.5 ppm of PACL as annual average consumption ,this treatment plant consume 803 kg per day, if he used the 8ppm dose of PACL plus 10ml/L sludge with PH equal 7.5, is obtained daily to191kg parsimony of coagulant consumption and yearly to 69.7 tones. As methodological aspect our findings was consonantly with results of Takdastan.A, Mirzaei.A [4], and McLane.J studies [13]. But Zhiwei.Zhou determined that at effective initial turbidity Less than 45 NTU and optimal pH of 6.5 to 7 the appropriated dose of mixed sludge for low Pollution water was 60 mL/L so this result do not consonantly with our findings [14].

CONCLUSION

According results of 4 stages examination to porous of PACL optimal dose with added recycled settled sludge determination and evaluate its effectiveness on coagulation process in hormozgan water treatment plant, the most coagulation occurred at 25ppm of PACL with 5ml/L of recycled sludge, but using of 8ppm PACL with 10ml/L of

sludge, with the besides being the combinated optimum dose has been convert optimal dose of PACL from 10ppm to 8ppm. Since no significant difference between efficiency of these two doses, with regarding conditions of optimized dose, this dose was defined to optimal dose. In this status turbidity and coliform removal efficiency were recovered to 96.8% and 91.2% consecutively. With addition of sludge, coliform and turbidity removal efficiency increases and there are significant linear relationship between volume of sludge injected on PACL's optimized dose and effluent turbidity and coliform that (R^2)coefficients are equal to 0.871 and 0.813 connectively(P_{value}<1%). Although in dose of more than10ml/L efficacy of turbidity removal is falling. If in this water treatment plant was added 8ppm of PAC Land 10ml/L of clarifier's recycled sludge in PH 7.5 is expected averagely 20% parsimony of PACL consumption equivalent to 193kg per day and 69.7 tons per year that is remarkable amount. PACl at low turbidity (2 to 6 NTU) and high turbidity (100 NTU) is an economical alternative instead of other coagulants such as $FeCl_3$ for remove of turbidity and TOC [15].

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