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Interrim report

Effect of NTA on the chemical flocculation of domestic waste waters

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The discharge of phosphorus is about 4 g (as P) and the water consumption close to 0.5 m^3 per person and day in urbanised regions of Sweden. The mean phosphorus concentration in sewage (influent at treatment plant) is thus about 8 mg/l at dry weather flow.

About 50 per cent of the total phosphorus in sewage originates from polyphosphates used as sequestering agents in household detergents. A partial replacement of the polyphosphates by organic sequestering (chelating) agents may, however, be advantageous, especially in heavy duty detergents. According to some manufacturers sodium nitrilotriacetate (NTA) may be substituted for up to 70-75 per cent of the detergent phosphates with no adverse effect on the detergent properties. A reduction of the detergent phosphates by 75 per cent would reduce the average concentration in sewage from 8 to about 5 mg/l. With 12-18 per cent of sodium NTA in detergents the average concentration of NTA (as free acid) in sewage would be within the range 3-6 mg/l. It has been claimed that such a substitution, from a water pollution point of view, would be beneficial by reducing the discharge of phosphorus *via* domestic sewage and thereby the gross "secondary" pollution of many natural waters. (This claim is not correct in as much as a more fargoing reduction of the phosphorus in sewage must be undertaken in most instances if the accelerated eutrophication of stagnant waters in urbanised regions is to be retarded.)

The logical extension of the biological methods for treating sewage is treatment with salts of multivalent cations at an appropriate pH to bring about a flocculation or precipitation of phosphate ion and of residual organic matter. In practice, either lime, aluminium sulphate (alum) or iron (III) salts can be used. In Sweden a cheap grade of aluminum sulphate, containing some iron, is expected to be the preferred chemical.

NTA will appear in sewage principally as the calcium chelate. As the aluminum and iron chelates are more stable, some interference may be expected if biologically treated sewage is to be flocculated with aluminum or iron (III) salts, provided that NTA has not been degraded at the preceding biological treatment.

The following presents the results from a study of the interference of NTA with the flocculation of domestic sewage with aluminum sulphate.

Procedure

The flocculations were made as conventional jar tests (1 litre beakers, thermostated and fitted with 30 r/min paddle stirrers). The flocculant used was aluminum sulphate ("unrefined" grade) supplied by Boliden AB. The pH giving the maximum removal of phosphate was found by experiments to be 5.6 - 6.2 pH-adjustments was made with hydrochloric acid or lime. The samples were stirred for 30 min. The flocs were then allowed to settle and the supernatant decanted and analysed for orthophosphate by conventional methods.

NTA (supplied by Rexolin Chemicals AB) was added as NaCaNTA. Concentrations given refer to the free acid. In separate experiments was demonstrated that all NTA remained in the clear supernatant on flocculation with alum.

During the experimental series, the waters used were stored at room temperature with gentle aeration. Storing thus for a few days had no significant effect on the results.

All values for PO_4-P are mean values of triple determinations.

Results

Effect of NTA at constant concentration of P

In the first experiment here presented the effect of NTA on the precipitation of phosphate with aluminum ion was examined at a low level of organic matter. The model used was a lake water* to which sodium dihydrogen phosphate** had been added to make a concentration of PO_4-P = 7.1 mg/l.

The results are summarised in Fig. 1. The effect of as much as 10 mg/l of NTA is fairly small. A removal of 80 to 95 per cent of the phosphates present requires about 10 mg/l more of alum when 10 mg/l of NTA is added. 10 mg of alum is equivalent to ca. 6 mg of NTA and it appears therefore that the interference of NTA is not stoichiometric.

In the second series of experiments biologically treated sewage with a BOD_7 of ca. 15 mg/l was used. PO_4-P was 2.3 mg/l. The flocculations were made at 15 and 5°C. The water thus differs from the previously used by being low in phosphorus but high in organic matter. The results are summarised in Fig. 2 and 3 and in Table 1. When 10 mg of NTA per litre is added, the amount of alum required to achieve a phosphate reduction of between 80 and 95 per cent increases with, on average, 15 and 25 mg/l at

*/ Tap water was tried but gave poor flocs.

**/ It was assumed for all models that any polyphosphate originally present in the untreated sewage would be hydrolysed in a preceding biological treatment.

15 and 5 ^{o}C, respectively. This corresponds to 0.9 and 1.4 equivalents of NTA, respectively.

The above results show that the presence of NTA in waste water leads to an increased consumption of aluminum sulphate for a given phosphate reduction. The increase seems not to be equivalent to the concentration of NTA but depend on other factors, for instance temperature and, may be, the amount of organic matter present.

Effect of the detergent composition on the removal of phosphorus

The above experiments do not take into account that the substitution of NTA for polyphosphate builders in detergents will result in a lower concentration of phosphates in sewage. To obtain models which would satisfactorily describe this, biologically treated sewage (PO_4-P = 3.5 mg/l; total P = 4.5 mg/l) was collected from a treatment plant on a Monday at 10 a.m. at which time detergent phosphorus is known by experience to be practically absent. The water was divided into five lots and NTA and sodium dihydrogenphosphate was added as follows (concentrations in mg/l):

Lot	NTA	PO_4-P added	PO_4-P (total)
I	0	0	3.5
II	0	4	7.5
III	0	8	11.5
IV	5	1	4.5
V	10	2	5.5

Lot I was used as control. Lots II and IV were assumed to simulate sewage with a normal load of detergents; lot II represented a sample with detergents containing only polyphosphates as builders and lot IV a sample where NTA was substituted for 75 per cent of the detergent phosphates.* Lots III and V were made to simulate a sewage with a high detergent load, such as may occur temporarily in a treatment plant.

The results are summarised in Table 2 and Fig. 4. It appears immediately that the substitution of NTA for polyphosphates results in a considerably reduced consumption of flocculant when sewage is to be treated for phosphorus removal. In other words, the decrease in demand for flocculant because of reduced phosphate concentration outweighs the increase caused by the interference from NTA.

The above results must be considered as qualitative only. Too many factors must be studied and controlled to make a quantitative evaluation of the effect of NTA on the flocculation of sewage possible. The present study clearly demonstrates, however, that no negative but rather a positive effect from NTA is to be expected on the chemical flocculation of sewage as long as the amount of detergent phosphates is correspondingly reduced.

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*/ If the detergent built on sodium tripolyphosphate contains 35 per cent STPP (normal for Sweden), the modified detergent will contain about 10 per cent of STPP and 17 per cent of sodium NTA, the reduced total weight being taken into account.

Table 1. Flocculation of secondary effluent (PO_4-P = 2,3 mg/l) at different concentrations of NTA

Alum, mg/l	30	40	50	90	100	130	150	
NTA, mg/l			Reduction of PO_4-P					t°C
0	48	72	90	97				
2	43	65	86	97				15
5	29	59	84	97				
10	23	41	72	95				
0	66		86		92	96	96	
2	56		83		91	95	97	5
5	54		80		89	94	96	
10	31		71		88	94	96	

Table 2. Flocculation at 15°C of secondary effluent at different levels of STPP and sodium NTA based detergents

Alum, mg/l			50	75	100	125	150	175	200	225
Lot	PO_4-P	NTA			Reduction of PO_4-P					
I	3.5	0	66	88	100	100				
II	7.5	0	36	60	76	91	100			
III	11.5	0		39	57	74	81	93	97	99
IV	4.5	5	55	83	92	100	100			
V	5.5	10	48	73	89	98	100			

Fig 1. Flocculation of lake water at 15 °C with soluble phosphate added to PO_4-P = 7.1 mg/l.

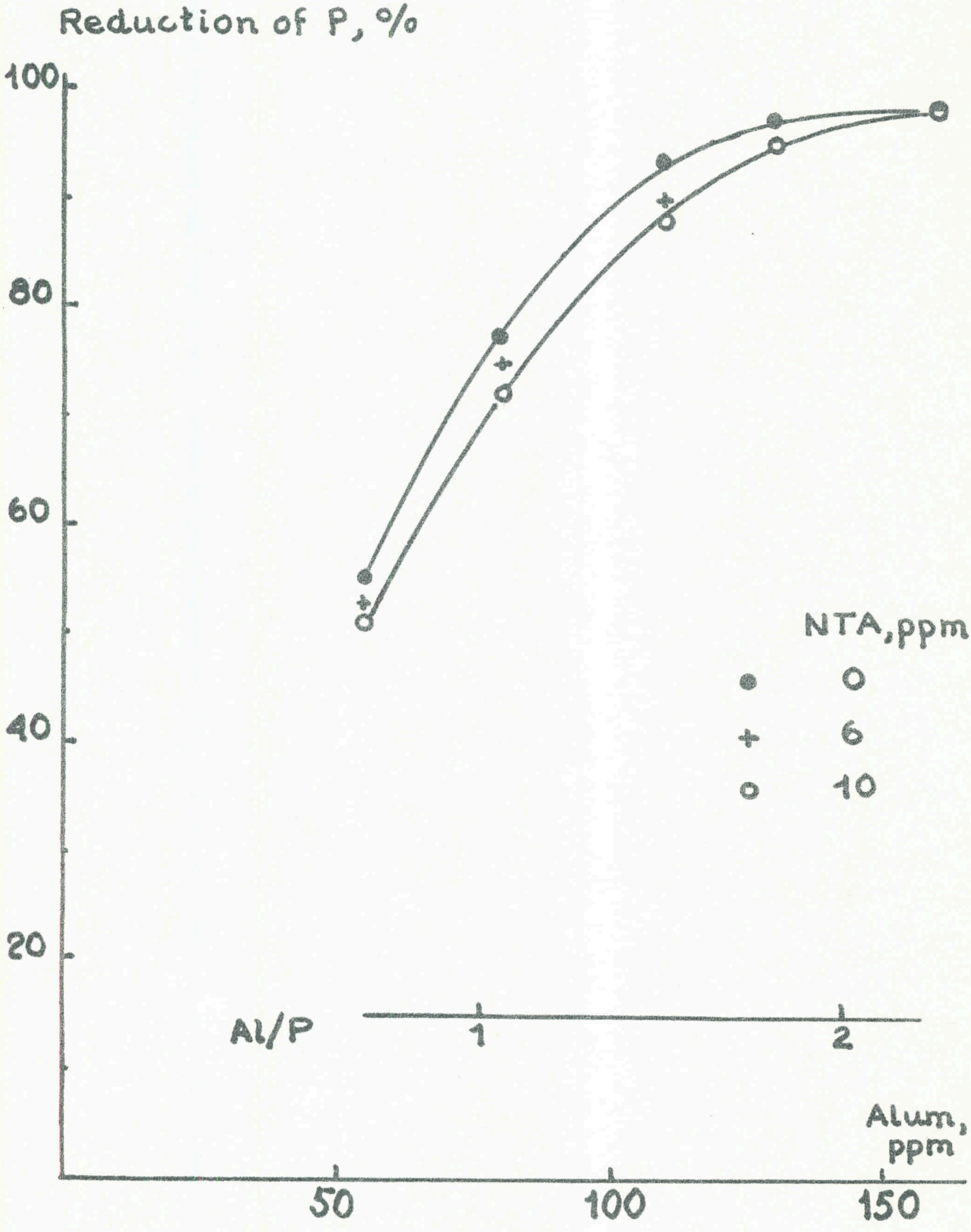

Fig 2. Flocculation of secondary effluent at 15°C. PO_4-P = 2.3 mg/l.

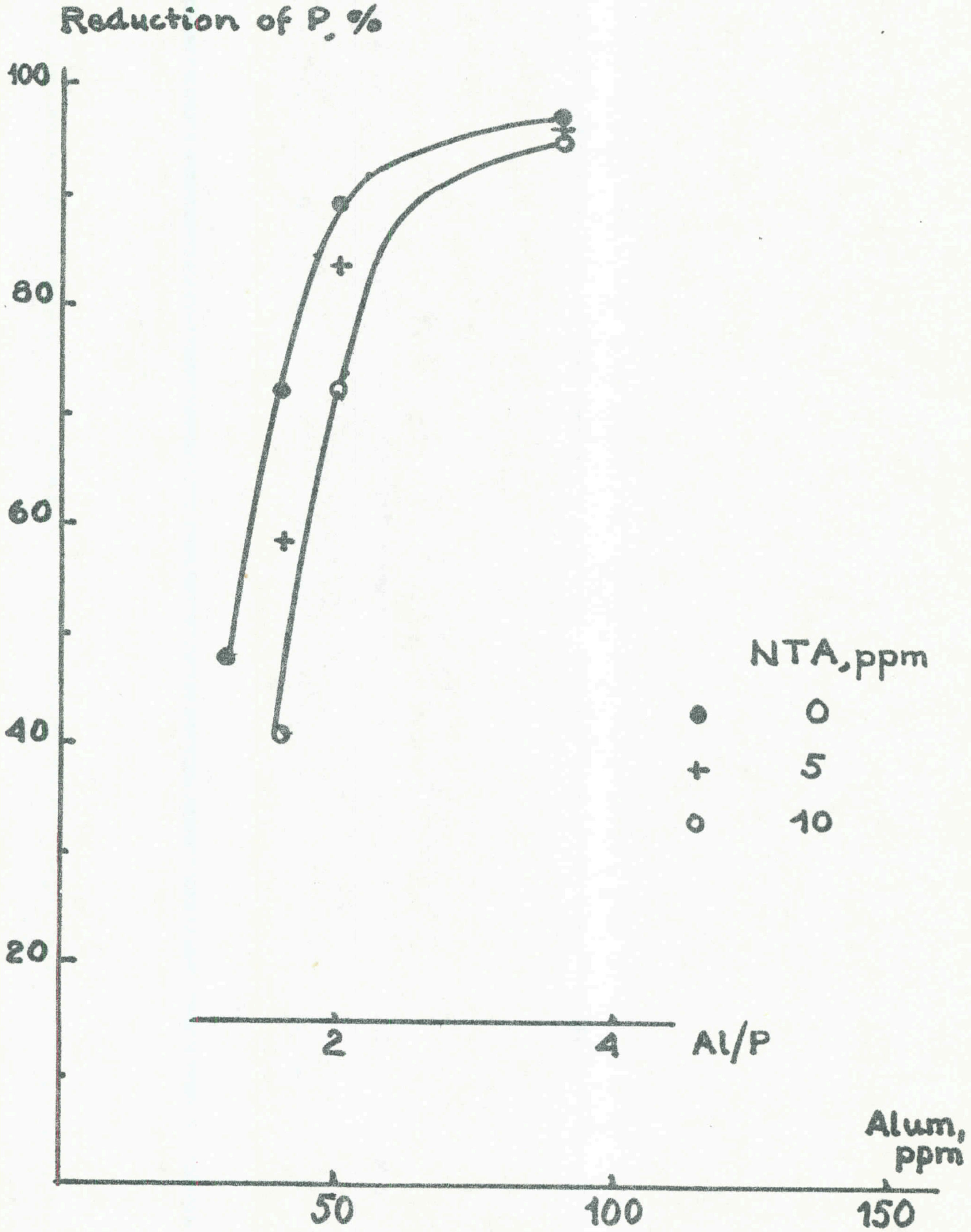

Fig 3. Flocculation of secondary effluent at 5°C. PO_4-P = 2.3 mg/l.

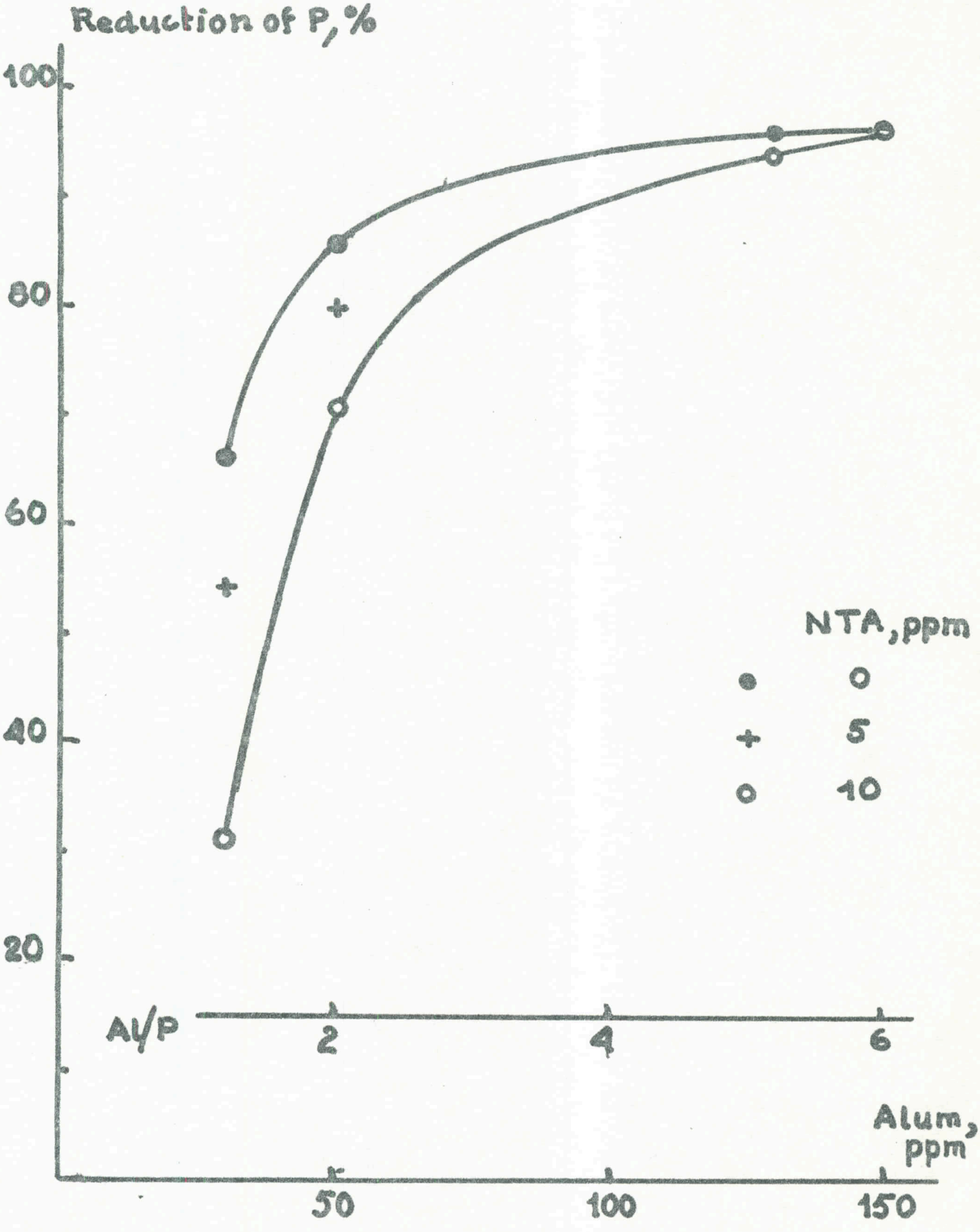

Fig 4. Flocculation of secondary effluent at different levels of STPP and NTA based detergents.