

**Interactive comment on
“Optimised conditions for application of organic flocculant aids in water
purification” by P. Polasek**

Response to Anonymous Referee #1

Received: December 15, 2009
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**Text in black are the Referee’s comment
Text in blue is the Author’s response**

GENERAL

This is a very thorough appraisal by the Referee for which I am very grateful. Therefore, it is not pleasant for me to say that some of the Referee’s comments present total confusion with respect to flocculants and misinterpretation of the purpose of the use of metal-ion-coagulant or cationic polyelectrolytes (CPE) with that of organic flocculant aid (OFA) which is clearly defined and described in my paper. I fail to understand why? In view of that I have asked two local engineers who by far are not as knowledgeable about water purification processes, as the Referee is, to read my paper and I must say they did not have problem in understanding and correctly interpreting it. Hence, I am totally confused with the Referee’s alleged problems in understanding my paper.

The difference between Organic Flocculant (OF) and Organic Flocculant Aid (OFA) is clearly evident from Table 1. Therefore, I fail to understand how ORGANIC FLOCCULANT in general and Organic Flocculant Aid (OFA) in particular can be confused with any metal-ion coagulant. Simply these are two different type of chemicals which are used for entirely different purposes. The OFA are polymers commonly anionic and non-ionic in character whilst metal-ion-coagulant or Organic Coagulants (referred to as CPE in my paper) are cationic in character.

The Referee’s statement that “some cationic polymers” can only act as a flocculant, whilst certain types can co-precipitate colour and therefore in part at least act like metal-ion coagulant is totally misleading as well as totally irrelevant for the paper under review. This is because this paper deals with organic flocculant aid (OFA) type polymers. In terms of Table 1 OFA is not a cationic polymer. In addition, I believe the Referee is not referring to organic polymers but rather to polymerized metal-ion-coagulant such as polyaluminium chloride. Furthermore, Organic Cationic Polymers (organic coagulants) referred to as CPE in Table 1, in accordance with my experience, cannot remove colour from water, at least not very efficiently – refer to Polasek & Mutl (2002): J.Water SA Vol. 28 No. 1, p. 69-82,83-89; and Polasek & Mutl (1995): New George Waterworks in Guidelines to coagulation and flocculation for surface water - Volume II: Evaluation of treatment process efficiency of different waterworks - Case Studies (PPA, Johannesburg, 1995) PPA publication. Both these paper can be e-mailed to the Referee upon request.

In the following I am going to respond to the Referee's comments as numbered by him. His comments are printed in black and my response thereto is in blue:

1. The paper is not reader friendly. I have read it several times, the final time I read it carefully to be sure I understood what the author is saying and it took far too long.

A few of my colleagues read this paper and had no difficulties reading, understanding and interpreting it – and they read it only one time.

2. I do not feel the paper has anything new to offer. It would seem to draw to readers attention information the author has previously published. If the paper includes previously unpublished work then this is not clear.

I am not surprised with the Referee opinion. This is because some of his comments for whatever the reason they paint a totally confused picture about my paper. It is difficult to understand that the Referee could not understand the topic of my paper at all. In addition, is there any author who came to the same results as are shown in Fig. 1 and transferred them to engineering practice in such a way that he is capable of operating lamella free clarifiers purifying surface water from impoundment at an upflow velocity exceeding $25 \text{ m}\cdot\text{h}^{-1}$? If not, then my paper must have something new to offer. Obviously, some information and conclusions resulting from the research described in this paper were already published in other papers but this paper together with the second paper on this topic already submitted to DWES deals in a holistic manner with the optimised conditions for the application of OFA which utilises the agglomeration capability of OFA to its maximum without detrimentally affecting the resultant quality of the purified water. May be, the DWES Editor should make available to the Referee my above mentioned second paper.

3. Several statements are made which should be justified by reference to appropriate published papers e.g. P214, approximately lines 5, 15 and 23.

On this page there is discussion of Figure 1 and hence only justifiable reference is this paper in general and Fig. 1 in particular. Is there any other author who published the same findings made in Fig 1 of my paper? If yes, then I would like to get reference to such paper.

4. P206.15: The categorization of organic flocculants (Table 1) does not entirely follow common international acceptance. For example, some cationic polymers can act only as a flocculant, whilst certain types can co-precipitate colour and therefore in part at least act like a metal-ion coagulant. Thus, whilst a 'flocculant' can only act as a supplement to use of a metal-ion coagulant in order to enhance floc formation, the 'cationic polymer coagulants' can be used to partially reduce the amount of metal-ion coagulant needed to achieve the desired quality (e.g. with respect to colour) of treated water. It is understood that the paper is concerned only with the application of polyelectrolytes used as a flocculant. It is noted that Table 1 does not help the reader distinguish between what the author in his text is distinguishing between 'cationic polyelectrolytes (CPE)' and 'organic flocculant aid (OFA)'

(a) In English terminology "flocculant" is rather a confusing terms because it refers to any chemical that can produce floc (another similarly confusing term is mixing). It seems to me that the Referee is preoccupied with the removal of colour from water. I have no alternative but to refer him to a paper by Polasek, Mutl (2002): J.Water SA Vol. 28 No. 1, p. 69-82,83-89; which compares the efficiencies attainable with different metal-ion-coagulants and different CPE. It seems to me, the Referee has a problem of distinguishing between FLOCCULANT as described

by him and FLOCCULANT AID as referred to in the paper – it may even be called AGGLOMERATION AID.

- (b) The Referee statement “It is understood that the paper is concerned only with the application of polyelectrolytes used as a flocculant” is false. The paper is not concerned with application of organic flocculant in general. It is concerned specifically with the application of Organic Flocculant Aid (OFA). OFA is commonly anionic or non-ionic in character, and always it is applied in combination with either a metal-ion-coagulant (using the Referee’s terminology) – destabilisation reagent used in the paper - and not usually with CPE. OFA does not function as a coagulant or coagulant aid, does not reduce dosage of metal-ion-coagulant, does not affect removal of colour on its own, etc. and all these aspects are clearly described in the paper. The specific purpose of OFA in water purification is to form large and strong agglomerates of a very high settling velocity. Because OFA is a lyophilic type polymer it can under the accustomed method of its application detrimentally influence the resultant quality of purified water – refer to Fig. 1. And this paper deals with the optimised conditions for OFA application under which any side effect of OFA on the resultant quality of purified water is eliminated. In my opinion Table 1 clearly distinguishes between individual types of polymers used in water purification and their chemical characteristics.
- (c) Another problem seems to be the categorisation of organic flocculants in Table1. Is the categorisation of Organic Flocculants in Table1 incorrect? If so, the Referee is requested to advice where, so that I can correct it accordingly. In addition, I would appreciate receiving the “common international acceptance of the categorization of organic flocculants” from the Referee.
- (d) In Table 1 in the Column Application next to Cationic I am going to replace: Purification Agent (CPE) with Organic Coagulant (CPE). The efficiency of or rather the inefficiency of cationic polyelectrolytes (CPE) on the overall efficiency of water purification process and removal of NOM (colour) is not a topic of the paper under review – it was dealt with in Polasek P & Mutl S (2002): J.Water SA Vol. 28 No. 1, p. 69-82,83-89 and Polasek & Mutl (1995): New George Waterworks in Guidelines to coagulation and flocculation for surface water - Volume II: Evaluation of treatment process efficiency of different waterworks - Case Studies (PPA, Johannesburg, 1995) PPA publication.

5. P206.25: The author states ‘It is common knowledge that application of OFA often results in poorer quality of purified water ... and inefficient filter backwashing.’ Yes but: it is the experience of many that poorly applied polymer and especially its excessive dose leads to filter problems. Commonly, the excessive polymer results in accumulation of sludge in the filters that cannot be removed by normal backwashing. This leads to mud-binding (mud-balls and filter bed cracking) and loss of filter efficiency. Usually, this has to be dealt with by replacing the filter media and resolving the dosing of polymer with respect to polymer choice, dosage and its control, and actual application. It is also advisable to have combined air-water wash. This is ultimately implied at the end of the paper P220, Conclusion 6.

It is evident from Figures 1 and 5 that an OFA dosage required under POA method is very low – usually a few hundredth or at most a few tenth of a milligram. In contrast, CPE dosage is as much as 10 - 100 times or even more times bigger than that of OFA. Furthermore, nothing in Conclusion 6 implies that replacement of sand is required when OFA is applied under the POA method – my experience with OFA formed suspension proves that neither filtration nor

backwashing is a problem with a good and efficient filter design. Filter sand must often be replaced when the CPE formed suspension is filtered and filter of a poor design is installed (for instance Paterson-Candy or Bi-water type filters and similar) and inadequate intensities of air scour and backwash water are applied instead of air+water combined backwashing. The problems described by the Referee are common problems with the use of cationic polymers and it was addressed in Polasek P & Mutl S (2002): J.Water SA Vol. 28 No. 1, p. 83-89; Reference to the problems with backwashing of OFA formed suspension will be added to the text.

6. In addition to use of abbreviations (e.g. OF, CPE and OFA) which the reader has to become familiar with, the author dangerously uses jargon, some of which is of his own making, e.g.:

- a. P206.5: 'destabilization (aggregation – CPE)' –
the following new paragraph will be added the manuscript in order to clarify the reasons for using this terminology: *Due to a variety of mechanisms that may be encountered in the transformation of impurities present in water into separable suspension the term coagulation does not reflect the basis of all partial processes taking place during the transformation of all kinds of colloidal impurities into readily separable flocs. It is more accurate to call this process aggregation and the flocs formed aggregates and the reagent used destabilisation reagent instead of coagulant. In this context the terms aggregation, aggregates and destabilisation reagent are used in this paper. The terms "destabilization and aggregation" are used in water purification literature for at least last 15 years and probably even longer. CPE is just abbreviation of Cationic PolyElectrolytes.*
- b. P206.7: Post-Orthokinetic Agglomeration (POA) –
a method developed by myself for OFA application which eliminates the side effects of OFA on the final quality of the purified water. The POPA method is apart of the High rate Clarification (HRC) technology which was developed for the intensification and acceleration of the water purification (clarification) process.
- c. P207.24: Inline high density suspension (IHDS) –
a method developed by myself which is part of HRC technology. The IHDS method is intended for the formation of dense aggregates (flocs), which are densified in the process of their formation. The IHDS method in contrast to the method of aggregate densification by sludge recirculation, which is used for instance in Degremont Densadeg type clarifier which was developed in response to HR sludge blanket type clarifier which incorporates the IHDS method. A comprehensive paper on IHDS will be published in J. Hydrol.Hydrochem in early 2010 – the manuscript of this paper has been submitted.
- d. P209.5: Measure of flocculation –
a tool facilitating indentification of the extent of aggregation coagulation/flocculation) process achieved by the (coagulating/ flocculating) system prior to addition of OFA.
- e. Fig.2: High Rate Clarification (HRC) technology –

a new generally applicable technology combining IHDS and POA processes which was developed for the intensification and acceleration of operation of clarifiers/sedimentation tanks – the HR sludge blanket clarifier incorporating the HRC technology has been operated at an upflow velocity at the sludge blanket level well above 25 m/h.

- f. The use of abbreviations has resulted in problems with using the definite (the) and indefinite (a/an) articles.

I am sorry for that, I am not native English speaker. If the Editor prefers to use the full description instead of abbreviation, the meaning of which is defined in the text I have no problem with that.

- g. P212.18: The statement concerning 'G*' stands for G(bar)' should have been dealt with so that it does not have to be made.

I am truly sorry for that. For drawing the Figures I am using the Slide program and have no idea how to insert G(bar) into a Figure. If somebody can advise me how to do it, I will most appreciate it and will include G(bar) the Figures immediately.

7. There is no mention of coagulation pH. In this day and age, no investigation of coagulation can be taken seriously without including measurement and preferably control and optimization of pH.

This paper is not about coagulation (destabilization of the particles of impurities), therefore, there is no need for any reference to coagulation pH. This paper is about agglomeration of the flocs that were already formed by preceding coagulation/flocculation process into large, strong and very fast settleable agglomerates. The importance of pH under which the process of floc formation takes place is another issue which does form part of this paper - it has been addressed in a paper by Polasek & Mutl (2005): Optimisation of reaction conditions of particle aggregation in water purification – back to basics. J.Water SA, 31, 1 p.62-72, 2005.

8. Table 3: Water temperature should be quoted when referring to specific clarifier (and filtration) rates.

I am sorry for that. The water temperature is referred to in Table 2 but it will be inserted to Table 3, too.

9. Miscellaneous queries include:

- a. The word 'purified' is frequently used but seems to have various meanings in that it may refer to quality after just sedimentation or after filtration.

The meaning of the purified water is always the same. It is the water that has been chemically treated. If the reference is made to jar tests than the purified water is that after sedimentation.

- b. P206.5: First use of 'CPE' without being defined.

Point taken, it will be corrected.

- c. When an aluminium or iron coagulant is referred to, i.e. destabilisation reagent', it would be better to say 'metal ion coagulant'.

Point taken – refer to 6a above.

- d. P207.22: ‘... agglomeration capacity is fully developed ...’ this kind of statement is made several times _ would it not be more appropriate to refer to flocculation being optimised or maximised?
Definitely not. I have no idea what the Referee is referring to when he states “flocculation being maximized”. I have never come across with this term and I have no idea what it could mean. Flocculation (or aggregation) being optimised makes sense to me if the Referee is referring to optimisation of the reaction conditions under which this process takes place. Alternatively, if he is referring to optimisation of hydrodynamic conditions under which this process takes place. But either of the above has nothing to do with the full development of the agglomeration capacity of OFA - it means what it says. The full development of agglomeration capacity of OFA means that the conditions in the system enable the OFA polymers chains to attain their maximum agglomeration capability – for instance, they are not sheared by the system or not utilized to restabilise already destabilized particles of impurities, etc. More on this topic is the second paper that I already submitted to DWES. May be the Referee should read and appraise this paper, too.
- e. The word ‘floc’ seems to have been used only once! It would be easier to the reader to use instead of saying the likes of ‘formed aggregates’.
Refer to the new paragraph in 6a that will be inserted to the manuscript.
- f. P208.6: what is relevance of ‘to the utmost benefit’?
The relevance is as mentioned in the sentence .. the influence of high intensity agitation on the inner structure of the aggregates being formed and the resultant increase in their density.
- g. P210: GHIA and P211: GLIA are not defined.
 \bar{G}_{HIA} stands for \bar{G} produced by High Intensity Agitation and \bar{G}_{LIA} stands for \bar{G} produced by Low Intensity Agitation. Point taken, it will be defined in the text.
- h. P211.3: ‘RPM’ is redundant.
Thanks, RPM will be deleted
- i. P211.23: Is the statement ‘-affix F means ...’ relevant?
Yes, it is relevant as it is used in Table 3.
- j. P212.13: The jar operated without OFA is not a ‘blind’ but a ‘reference’. Thanks, it will be changed
- k. P219: What do reference to CCF and $\dot{\epsilon}$ achieve?
The quantity CCF will be corrected to CF in terms of Table 3. Should I include calculations of both CF and $\bar{\varphi}$ or is the reference to it in Methods acceptable?
- l. Table 2: The normal international convention for referring to litres is to use capital ‘L’. Table 2: The title says ‘average quality’ yet ranges are quoted for turbidity and colour.
Thanks, this will be corrected in the manuscript.
- m. Table 3:P What do MA, MI, PR and NA refer to?

These quantities represent aggregates size-fraction in the tested profile of the works. MA means a portion of macro-aggregates, MI portion of micro-aggregates, PR portion of Primary aggregates and NA portion of non-aggregated particles of impurities and clearly described in Table 3. These portions are determined by the test of aggregation. Should the calculations of these portions of aggregate be included in the manuscript as the reference to it in the Methods is not acceptable?

- n. Fig.1: What does a value of $\gamma=0$ actually mean? Also, isn't γ simply a way of expressing the value of GT as a normalised value.
 $\gamma = 0$ means that the OFA is added together with (or at the same time as) the destabilisation (metal ion coagulant)/aggregation reagent. Refer to 6d above
10. Conclusions: conclusions should relate directly to the information presented in the paper. New information or statements should not be made e.g.:
- Conclusion 1 does not arise from the evidence presented in the paper.
This clearly transpires from Figure 1 and it is described on Page 214, line 1 to 11.
 - Conclusion 6 – 'use of coarser filter media and combined air + water for backwashing' is a new statement.
Thanks, it will be added to the text.
11. The basic message of the paper seems to be that:
- metal-ion coagulant dose and its application (and coagulation pH) must be optimised; effective application requires rapid dispersion.
False.
 - polymer dose and its application must be optimized, and again effective application requires rapid dispersion followed by conditions to allow floc growth
There is nothing novel in this message which was first being made about 40 years ago, (e.g. Miller, Robinson & West, 1965; Yadav & West, 1975) although the significance of what might be called 'delay time' between dosing of coagulant and subsequent dosing of a polymer and also between dosing of a polymer and entry into a clarifier is taking time to be better understood (Bache & Gregory, 2007). Also well known is the importance of adequate (high enough) velocity gradient (G) when coagulant is dosed and that if it is not then coagulant dose may need to be greater to compensate for its poor dispersal (Kawamura, 2000; Bratby, 2008). Miller DG, Robinson M & West JT (1965) Water Treatment Process – 1, Rep No. WRA TR43, WRc, Swindon, UK. Yadav NP & West JT (1975) The Effect of Delay Time on Floc Blanket Efficiency, Rep No. TR9, WRc, Swindon, UK Bache DH & Gregory R (2007) Flocs in water Treatment, IWA Publishing. Kawamura S (2000) Integrated Design and Operation of Water Treatment Facilities, John Wiley & Sons. Bratby J (2008) Coagulation and Flocculation, IWA Publishing.
False.
The basic message of this paper is how to apply OFA so that its maximum agglomeration potential is utilised for the formation of the fastest settleable agglomerates whilst the resultant quality of purified water is not worsened because of the hydrophilic properties of OFA.

Interactive comment on Drink. Water Eng. Sci. Discuss., 2, 205, 2009.

Modifications to the manuscript are required as follows:

Page 206, Line5: add behind destabilisation reagent (hydrolysing metal-ion-coagulant) or aggregation reagent (cationic polyelectrolyte – CPE) and delete (aggregation – CPE)

Page 207, Line 1: replace *(coagulant)* with *(hydrolysing metal-ion-coagulant)*;

Page 207, line 24: replace *In the paper* with *In this paper*;

Page 208, line7: replace .. *primary aggregates and the micro-aggregates* with *aggregates being formed*;

Page 208, line 8: after *density* delete *process*;

Page 208, line 10: Add the following new paragraph: *Due to a variety of mechanisms that may be encountered in the transformation of impurities present in water into separable suspension the term coagulation does not reflect the basis of all partial processes taking place during the transformation of all kinds of colloidal impurities into readily separable flocs. It is more accurate to call this process aggregation and the flocs formed aggregates and the reagent used destabilisation reagent instead of coagulant. In this context the terms aggregation, aggregates and destabilisation reagent are used in this paper.*

Page 210, line21: behind *a high* add *intensity agitation characterised by a high*;

Page 210, lines 25and 26: delete *root-mean-square*;

Page 211, line 3: delete *RPM*;

Page 211, line 6: behind *corresponding to* add *low intensity agitation characterised by a root-mean-square velocity gradient...*;

Page 211, line 26: behind *test of aggregation* add the following *which enables the aggregates formed to be ascribed to one of the four technologically basic size-categories, namely: nonaggregated particles (NA), primary aggregates (PR), micro-aggregates (MI) and macro-aggregates (MA) ..*;

Page 211, line 27: after *attained* insert φ and after *attainable* insert $\bar{\varphi}$;

Page 213, lines 2 and 7: change *blind* for *reference*;

Page 213, line 6: behind *improvement in* add *the quality of purified water and ...*;

Page 214, line 14: change *was* for *is*;

Page 214, line 16: move here Page 215, lines 1 to 11;

Page 219, line 4, 5 and 6: change C_cF for CF ;

Page 219, line 11: Insert: *Operational experience with filtration of OFA formed suspension proved the necessity for coarser filter media and combined air + water backwashing.*

Page 220, line17: behind *destabilisation reagent* add *used* and behind *reaction* replace *conditions* with *pH*;

Tables 1, 2 and 3 – attached with the new corrections

Table 1: Classification of organic flocculants

ORIGIN		CHEMICAL CHARACTERISTIC			APPLICATION	
NATURAL POLYMERS	CHEMICALLY TREATED	POLYELECTROLYTES	CATIONIC	ORGANIC COAGULANT (CPE)	FILTRATION AID (OFiA)	
	CHEMICALLY UNTREATED		ANIONIC			
SYNTHETIC POLYMERS			AMPHOLYTE	ORGANIC FLOCCULATION AID (OFA)		
			MIXED			
		NONELECTROLYTES	NON-IONIC			

Table 2: The quality of different raw waters used in the study

DETERMINANT	UNITS	VAAL DAM	LOCH ATHLONE DAM	SAULSPOORT DAM
Temperature	°C	18	12-25	12 – 25
pH	-	8.2	7.7	7.4 – 8.2
Turbidity	NTU	160	50 - 690	30 - 250
Colour	mg Pt. L ⁻¹	17.5	5 – 15	10 - 40
Total Hardness	mg CaCO ₃ . L ⁻¹	71	108	90 - 160
Total alkalinity	mg CaCO ₃ . L ⁻¹	65	75	75 – 140
COD _{Mn}	mg O ₂ . L ⁻¹	4.2	3.4	6.5
THM – potential value	µg CHCl ₃ .L ⁻¹	-	-	878

TABLE 3: COMPARISON OF PERFORMANCE EFFICIENCY OF DIFFERENT TYPE CLARIFIERS

Raw water: Mixture of Saulspoor Dam and Loch Athlone Dam waters
 Raw water turbidity: $C_0 = 102$ NTU
 $C_0F = 54$ NTU MA - portion of macro-aggregates
 Water temperature: 18°C MI - portion of micro-aggregates
 Destabilisation reagent: Aluminium sulphate PR - portion of primary-aggregates
 Optimum dosage - Tu removal: As shown NA - portion of nonaggregated / nonseparable particles

TYPE OF CLARIFIER	POINT OF MEASUREMENT	MEASURE OF FLOCCULATION γ	UPFLOW VELOCITY AT SLUDGE BLANKET LEVEL [m/h]	DOSING RATE		TURBIDITY		AGGREGATE SIZE-FRACTIONS			
				$\text{Al}_2(\text{SO}_4)_3$ [mg/l]	SF-A110** [mg/l]	C [NTU]	CF [NTU]	MA [%]	MI [%]	PR [%]	NA [%]
PRETREATOR	Flocculation chamber outlet	0,56	1,5	60	0	102	4,9	75,5	14,7	6,2	3,6
	Hydraulic jump	0,66				102	4,0	17,6	57,9	22,3	2,2
	Clarifier outlet					7,1	1,5	1,5	2,5	1,6	1,4
	Filtrate					0,50	0,32	0,0	0,0	0,18	0,32
CLARIFLOCCULATOR	Flocculation chamber outlet	0,56	1,2	60	0	102	4,9	75,5	14,7	6,2	3,6
	Clarifier outlet					7,2	2,9	1,2	1,9	1,4	2,7
	Filtrate *					0,71	0,53	0,0	0,0	0,18	0,53
HR CLARIFIER	Flocculation chamber outlet	0,99	15,5	52	0,172	102	1,7	50	32,6	16,1	1,3
	Clarifier outlet					7,0	1,4	2,6	1,9	1,4	1,2
	Filtrate*					0,71	0,53	0,0	0,0	0,18	0,53

* Clariflocculator and HR clarifier outlets combined prior to filtration

** SF-A110 dissolved in plain tap water

Figure 1: Significance of γ value reached prior to OFA addition on the quality of purified water

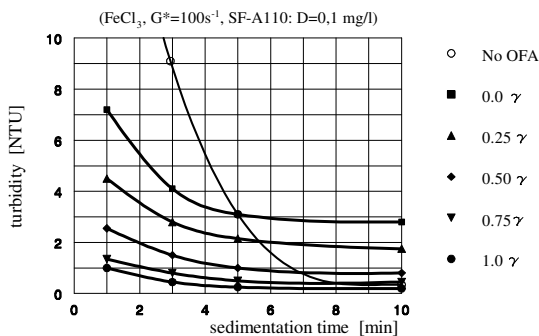


Figure 2: Illustration of the high rate clarification (WRC) technology

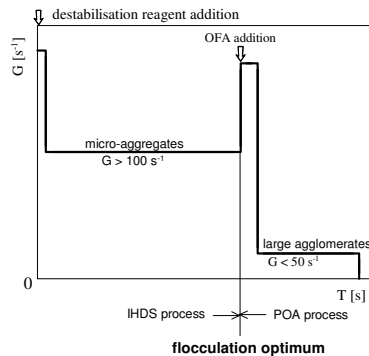


Figure 3: Influence of OFA dosage and γ reached prior to OFA addition on the quality of purified water

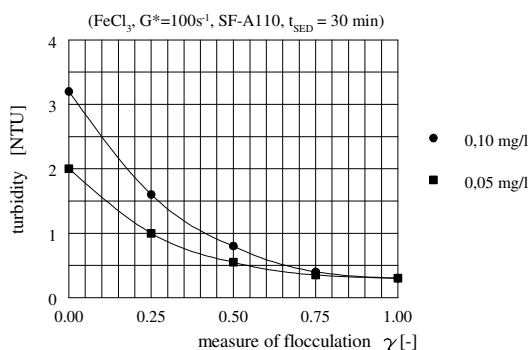
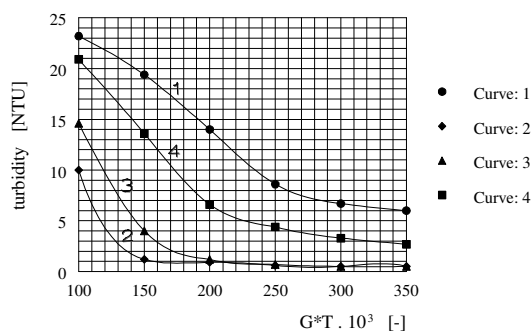


Figure 4: Influence of sludge recirculation on kinetics of aggregation process



Legend to Figure 4

Curves:

- 1 - the raw water purified with activated silica ($D = 2.0 \text{ mg/l}$) and lime ($D = 80 \text{ mg/l}$),
- 2 - the raw water was first inoculated with sediment from the previous test (curve 1) and then purified with activated silica ($D = 2.0 \text{ mg/l}$) and lime ($D = 80 \text{ mg/l}$),
- 3 - the raw water purified lime ($D = 80 \text{ mg/l}$) and the formed suspension agglomerated with OFA under the conditions of the POA process (dosage of SF-A110 $D = 0.1 \text{ mg/l}$),
- 4 - the raw water was first inoculated with sediment from the previous test (curve 3) and then purified lime ($D = 80 \text{ mg/l}$) and the formed suspension agglomerated with OFA under the conditions of the POA process (dosage of SF-A110 $D = 0.1 \text{ mg/l}$).