Selection of polymers and optimization of the conditions of primary wastewater treatment

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Abstract

Determine dependence efficiency of filtering systems Salsness (degree of removal of suspended solids, turbidity degree of reduction, performance hydraulic filter, etc.) of the input characteristics of water pollution and corrective actions process (adding various reagents). The conditions and reagents were determined, which together provide a high degree of removal of suspended solids at a minimum cost for real wastewater.

Аннотация

Определение зависимости эффективности работы фильтрующих систем Salsness (степень удаления взвешенных частиц, уменьшение мутности, гидравлическая производительность фильтра) от входящих характеристик сточной воды и добавляемых реагентов. Определены условия и тип реагентов, которые вместе обеспечивают максимальный степень удаления взвешенных веществ при минимальных экономических затратах.

Keywords: Optimization of coagulation, Salsnes Filter, Mechanical filtration

Introduction

With constant population growth, many water treatment plants met the need to increase the productivity of plants, but are often limited to a certain area and are unable to install additional equipment. This is especially true of primary wastewater treatment systems that include settling tanks and clarifiers. This type of equipment requires large areas of the surface. Therefore, this research is a vital question on finding alternative world technologies that can replace septic tanks on equipment that requires less space for both Ukraine and all over the world, especially in countries with limited territorial resources (China, Bangladesh, India, Japan and Europe).

The object of this work is the study of filtering system Salsnes, Norwegian production. Filtering systems Salsnes require at least 10% of the land, which is under construction lagoons. By replacing the classical primary treatment for Salsness technology significant performance increase can be achieved using the same land resources. Filtering systems Salsnes is able to remove 50% of suspended solids and 20% of microorganisms. The objective of this work is to improve filtration process through the use of chemicals (flocculants, coagulants).

Purpose - to find out how the Salsnes filters work with chemical reagents, and choose reagents and the best conditions of the filtration process which gives maximizes the degree of removal of suspended solids, and minimal cost of reagents. This work is new to the area as Ukraine and Europe. Not all European plant is upgrading primary wastewater treatment. There are not plants in Ukraine which change a clarifier and settler to other methods of removal suspended solids. The process of Wastewater Treatment usually involves several stages, each of them may use different methods of wastewater treatment and appropriate technological equipment. This situation is due to many methods especially fine purification which cannot work on this water because there are so much suspended solids or emulsion in waste water.

Accordingly to this, there is a need pretreatment of wastewater before applying basic methods of purification. Application of step purification for wastewater is caused by getting a combination of several treatment types is possible to reach a necessary rate of removal SS for minimal cost. Every wastewater treatment plant is using different amounts of water stages. It depends of wastewater treatment plants, purification methods which used and the composition of water. To develop the information system of sewage treatment processes should be considered on the basis of a more generalized approach.

The most rational is likely to be the separation process effluent into four stages, according to the division of pollutants based on their physical state classification academician Kulski.

At the first stage of wastewater treatment it is necessary to remove large particles of suspended solids and coarse impurities. If the data of pollution is absent in wastewater, you need to start treating wastewater from the second stage at which the removal of almost all solids, and is preparing for further purification of wastewater, namely, reducing aggressiveness sewage, reducing unacceptable concentrations of certain pollutants. The third stage - biological treatment to remove phosphates and nitrogen compounds. The use of specific methods of wastewater treatment, or their combination at each stage of treatment is determined by the chemical composition and physical properties of wastewater. Depending on the presence or absence of certain classes of pollutants in sewage may exclude some stage of purification.

It is not difficult to find out that the second and the third stages of treatment are an integral part of any technological scheme for wastewater treatment. Thus purification steps - the first and the second stage of wastewater treatment are the foundation of any process of cleaning. The first stage is the pre-treatment and mainly consists of sedimentation step as a settler. For further removal of suspended solids in the form of colloidal systems should intensify the process of deposition - coagulants and flocculants added, followed by settling (mostly). Some treatment plants try to replace defending process (step 2) on the filtration process.

Mechanical filtration techniques

Filtration is separation process in which a mixture of liquid and solid passed through porous material, which detain solid particles and liquid phase passes. Filtration process has three main mechanisms: detention, separating and fixing. The significance of each depends on the characteristics of detained particles and the used filter material.

There are two main types of ***detention mechanism***:

Mechanical filtration: in this case it will be the retention of particles larger than the filter holes or passages formed already detained filter particles. This mechanism is predominant when using fine filtration basics type sieve, filter cartridge.

The sludge on the filter material: suspended particles moving under the stream of water, their size relative to the size of the pores cannot let them linger, but multiple contacts between the particles filtering material and ensure its retention. This type of mechanism prevails at a depth filtration layer.

The mechanism of fixation

Fixing the particles on the surface of the filter material facilitates low velocity water. This process is driven by forces that are purely physical nature (jamming, holding, etc.) or by sorption, especially Van der Vals.

Mechanisms of separation

Under the influence of these mechanisms decreases the space between grains feed material that are coated separated particles. Previously arrested sediment may partially stall a faster flow and get to the filtrate, or move into the depths of the filter material. During filtration driving force is the pressure difference before and after the filter. As a result, filtration, sediment clogging of the pores, causing pressure drops power, as this is true, the smaller the holes in the filter material, the smaller hydraulic performance.

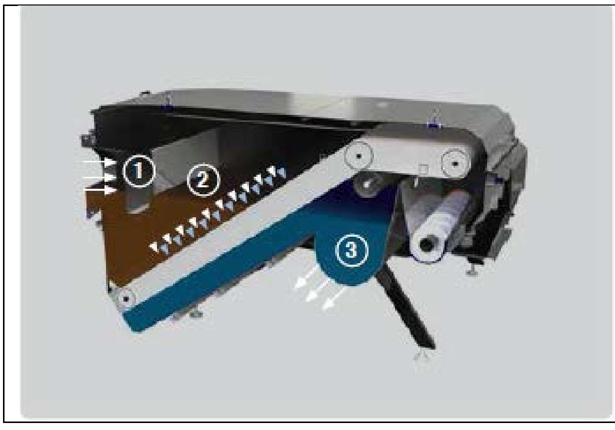
$$\Delta P = \Delta P_0 \cdot (1 - a \cdot \sigma),$$

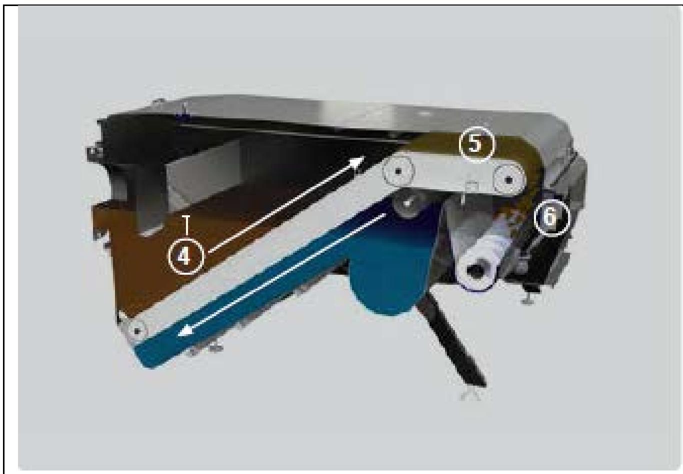
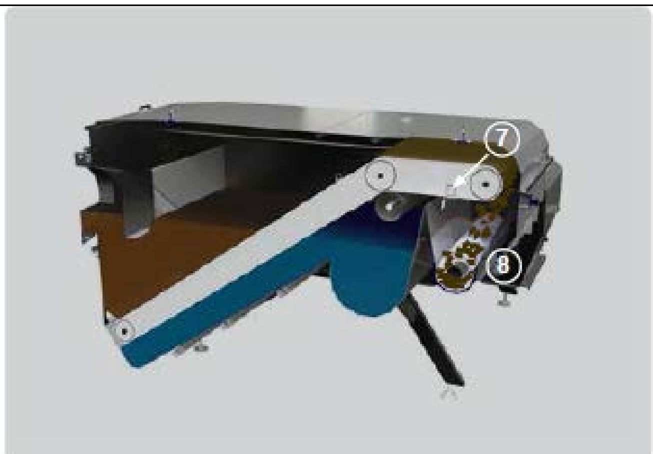
where, ΔP hydraulic capacity, σ - specific volume detained precipitate on the surface of the filter unit, a - an empirical coefficient. Thus, the normal filtering process must either increase the pressure supplied to the filter layer or conduct means to remove sediment from the surface of the filter ("back wash", etc.).

Salsnes Filter technology

In a Salsnes filter system solids separation, sludge thickening and dewatering are performed in one compact unit, removing >50% TSS, >20% BOD and producing drier sludge (20–30% DM). A Salsnes Filter system can completely replace conventional primary treatment and does so in a fraction of the footprint, at 30 – 60% lower capital cost and with significantly lower total lifecycle costs. What's more, sludge handling, transportation and disposal costs are drastically reduced. Today, Salsnes Filter systems are installed around the world in a variety of applications within municipal wastewater treatment plants and in challenging industrial solids separation applications. Cost-effective, compact, high-performing, chemical-free and sustainable – the Salsnes Filter system defines eco-efficient.

Table 1 Technology of work Salsnes Filter.

	1. Wastewater enters the inlet chamber. 2. The solids above the filtermesh create a "filter mat." The mat enhances separation performance as particles build-up on the mesh, creating progressively smaller holes that retain increasingly smaller particles. 3. Water that is filtered past the mesh exits through the outlet.

<table>
<tr><td>
</td><td>4. Wastewater influent rises to a certain level (measured by a sensor) and the filtermesh starts to rotate like a conveyor belt, transporting sludge and enabling the thickening process.
5. Gravity thickens the sludge to 3–8% DM.
6. Sludge drops into the collection area.</td></tr>
<tr><td>
</td><td>7. Using air (not water) the Air Knife automatic cleaning system removes any remaining sludge from the filtermesh into the collection area.
8. A screw press further dewaters the sludge to 20 –30% DM before it exits the unit.</td></tr>
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Compared To Conventional Primary Treatment, a Salsnes Filter System Can Offer:

• 30 – 60% lower investment cost.

• 1/10th the land requirements.

• Integrated thickening and dewatering.

• Significantly lower lifecycle costs.

• Smaller volume of drier sludge that reduces disposal costs.

• Less civil works (no concrete basins required).

• Higher removal of TSS (>50%) and BOD (>20%) – with the ability to design systems for up to 80% TSS removal.

• Primary sludge with higher energy value.

• Fully-automated equipment.

Experimental part

1. Selection of the best polymer.

It is necessary to check all polymers different companies such as Kemira, BASF (Zetag) and SNF. After Jar Test the relationship between degree of removal turbidity and dosage of polymer was obtained. Also the optimal dosage of polymer was selected based on thinking the maximum degree of removal and minimum dosage for economic efficiency. The best dosage of polymer was calculated in "mg (Activity Component)/ g SS" it means that rate of polymer on 1 g Suspended solids. Cells which were selected in yellow color are the best dosage for every polymer.

Table 2 Result relationship between degree of removal turbidity and dosage of polymer.

Name of polymer	% Degree of removal turbidity						
	Dosage of polymer, µl						Best Dosage
	200	400	600	800	1000	1500	mg/g SS
1	2	3	4	5	6	7	8
c1	22	24	31	34	38	35	7,1
c2	31	33	32	36	30	37	10,4
c3	23	32	34	35	36	42	12,8
c4	19	26	31	32	37	36	8,5
c5	19	32	30	35	32	40	12,8
c6	30	33	36	40	43	48	12,8
c7	33	31	31	42	45	49	12,8
c8	7	14	15	14	21	16	9,3
1	2	3	4	5	6	7	8
CT1	36	35	41	42	44	47	19,5
CT2	26	27	46	50	57	62	13,9
CT3	20	23	28	26	31	38	13,9
CT4	17	21	22	24	28	55	13,9
CT5	32	33	37	39	40	46	12,2
CT6	32	32	36	29	34	40	12,2
CT7	28	34	38	36	36	40	12,2
CT8	32	40	43	42	45	47	8,1
CT9	34	39	41	44	47	41	8,1
CT10	31	34	38	39	42	45	8,1
Zetag 1	44	51	54	56	61	65	9,9
Zetag 2	38	39	44	36	40	41	3,9
Zetag 3	45	51	55	52	54	54	3,9
Zetag 4	41	45	43	46	43	42	5,3
Zetag 5	55	55	58	60	62	60	6,6

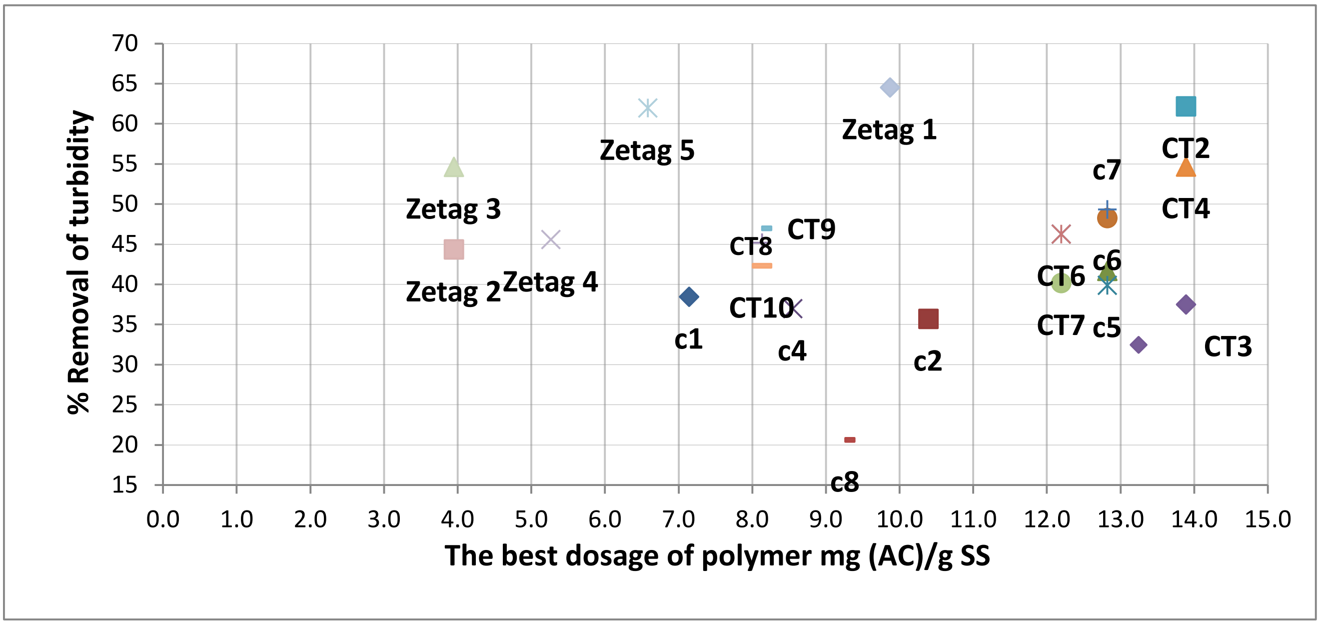

Figure 1 Relationship between removal of turbidity and tested polymers.

That is for selection the best polymer, it is necessary select polymers which would have the higher degree of removal and the smaller dosage of polymer.

The best polymers are Zetag1, CT2, Zetag3.

2. Optimization of the flocculation conditions.

After that when the best polymers were selected, it is necessary to make a optimization conditions of flocculation process. It is needed to change speed of mixing. “Rapid mixing” 300 to 400 rpm and “Slow mixing” 40 to 50 rpm. Selection of the best conditions based of the highest rate of degree turbidity.

Table 3 Result relationship between rate of degree removal turbidity and G values.

				Results based on % Turbidity removal				
				Primary WW				
Rapid Mix (rpm)	Rapid Mix (sec)	Slow Mix (rpm)	Slow Mix (min)	G (Rapid Mix)	G (Slow mix)	Zetag 1 (1.5mg/l)	CT 2 (1.5 mg/l)	Zetag 3 (0.6 mg/L)
300	10	30	5	334	24	61	55	48
		50	5	334	31	65	51	49
300	20	30	5	334	24	63	54	46
		50	5	334	31	65	59	45
400	10	30	5	525	24	65	53	43
		50	5	525	31	66	56	47
400	20	30	5	525	24	60	52	46
		50	5	525	31	64	53	46

Table 4 The best conditions for selected polymer.

Name of Polymer	Dose	Condtions of flocculation process						Removal of turbidity
		Speed	Time	G	Speed	Time	G	
	mg/g SS	rpm	sec	sec^{-1}	rpm	sec	sec^{-1}	%
Zetag 1	12	400	10	525	50	300	31	66
CT 2	10,7	300	20	334	50	300	31	59
Zetag 3	4,3	300	10	334	50	300	31	49

3 Checking SF in working with coagulant PAX 18 and choosing the best pair coagulant-flocculants.

This work is the same like in the step 1. After Jar test date of relationship between rate of degree removal turbidity and dosage of polymer was obtained (but dosage of coagulant PAX 18 was known – 50 μl). The best dosages of polymer were selected like in the step 1. It is necessary to get the higher level of removal turbidity and the smaller dosage of polymer.

The smallest dosage of polymer and highest level of removal turbidity show two couple of coagulant-flocculants:

1)Pax 18+Zetag 1;
2)Pax 18+Zetag2.

Table 5 Relationship between degree of removal turbidity and dosage of polymer

Name of polymer	% Removal turbidity						Best dosage
	Dosage of polymer, μg						
	200	400	600	800	1000	1500	mg/g SS
CT 2	68	67	74	63	53	79	3,5
Zetag 1	91	96	93	93	93	86	2,4
Zetag 3	86	76	80	64	82	83	1,2
Zetag 2	89	85	83	92	92	92	1,2
Zetag 4	74	74	68	59	69	87	8,7
A 1	96	95	97	96	97	96	1,9
EM	93	96	96	96	94	97	4,7
EAN	92	93	95	87	85	94	1,9

The next step is the optimization conditions of coagulation process and also dosage of coagulant when dosages of polymer are known (400 and 200 μg).

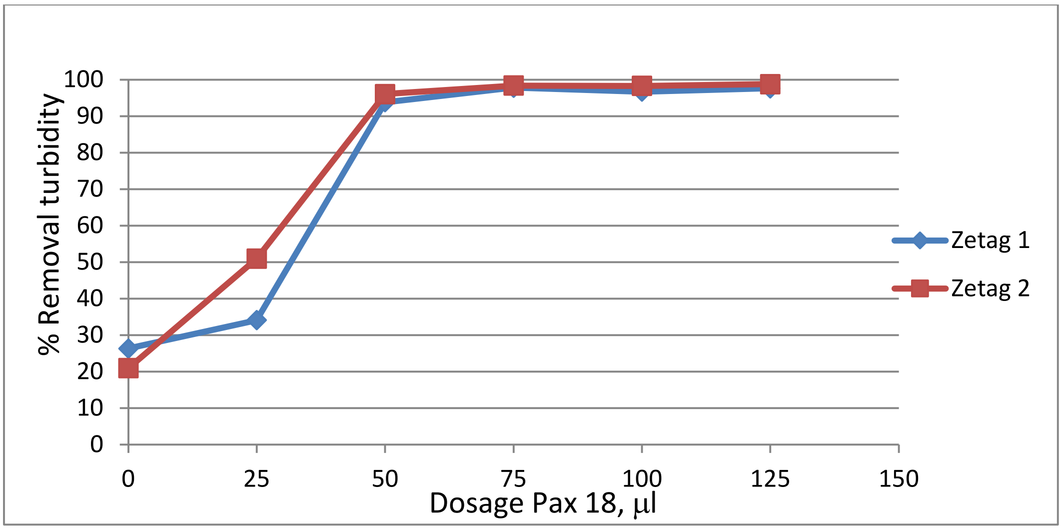

Figure 2 Relationship between rate of removal turbidity and dosage of PAX 18

This figure shows that the best dosages are 75 µl for polymer Zetag1 and Zetag2.

5. Conduct SF without adding reagents with flocculants, coagulants and coagulant-flocculants.

After when the best polymers, coagulants, couple coagulant-flocculants and conditions are known, it is possible to make Salsnes Filtration with different sizes of filter material to know how SF work with different reagents.

Table 6 Results of Salsnes Filtation

Name	**Dimension**	**Polymer 1**	**Polymer 2**	**Polymer 3**	**Only Coagulant**	**Coagulant+polymer**	
		Zetag 1	**CT 2**	**Zetag 3**	**PAX 18**	**Zetag 2 + PAX18**	**Zetag 1 + PAX18**
Dosage	mg(AC)/ g SS	12	7,5	3	-	1,2	2,4
Rapid Mixing	rpm	400	300	300	400	200	200
Time	sec	10	20	10	10	10	10
G values	sec^{-1}	525	334	334	525	183	183
Slow Mixing	rpm	50	50	50	40	40	40
Time	sec	5	5	5	5	2	2
G values	sec^{-1}	31	31	31	23	23	23
Highest rate of removal turbidity	%	**77**	**79**	**75**	**59**	**99**	**98**
Size mesch	µm	90	250	90	90	33	75x55
Hydraulic capacity	m^3/m^2-hour	**16,2**	**27,2**	**12,4**	**10,4**	**3,2**	**3,7**

This table shows how work SF with different reagent or without them. This date can help to understand which conditions and reagents are needed to use to solve any problem. We can see that couple coagulant-flocculants give the best removal of suspended solids but this couple have a smallest hydraulic capacity. If use this filter like the pre-purification system before biological treatment, it is possible to use only polymers which will give level of removal SS about 80% and the highest hydraulic capacity 27 m^3/m^2-hour.

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