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DESIGN BASIS AND OPERATION OF SMALL WASTEWATER TREATMENT PLANTS FOR ORGANICS AND PHOSPHORUS REMOVAL IN LOW TEMPERATURES — FINNISH EXPERIENCE

The package wastewater treatment plants, if properly designed, operated, and maintained, can usually provide satisfactory performance. This paper describes the Finnish experience in design and operation of small wastewater treatment plants. Selected package plants are described and the performance results given.

1. INTRODUCTION

Since urban and industrial pollution in Finland has mainly affected water resources, the water protection is generally considered as the first priority in environmental pollution control.

Inland waters represent about 12% of Finland's total area and consist mainly of shallow lakes with a low nutrient humus load from natural sources. This causes depletion of the dissolved oxygen content in the lake's water bodies, especially during the winter, as well as signifies their response to the nutrients contained in discharged wastewaters.

Since according to Finnish standards the wastewater treatment requirements are for BOD_7 less than 30 mg/dm^{-3}, and for residual phosphorus less than 1.5 mg/dm^{-3}, therefore in many cases the efficiency of BOD and phosphorus removal should exceed 95% and 90%, respectively, and water pollution control measures need to comply with these values.

2. DESIGN BASIS FOR WASTEWATER TREATMENT PROCESSES AND SLUDGE HANDLING

2.1. ORGANICS REMOVAL BY ACTIVATED SLUDGE

The activated sludge plants are the most widely used in Finland for the organic matter removal from municipal and industrial wastewaters. The design of an aeration tank is based on the sludge load, and in a small plant the normal organic loading rate should

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be smaller than 0.3 kg BOD_7/kg MLSS·d. In the extended aeration system, used extensively for package plants where the operation reliability and the easiness of sludge handling are seeked, the sludge loads should be about 0.05-0.1 kg BOD_7/kg MLSS·d. Volumetric organic loadings are usually up to 1.0 kg $BOD_7/m^3 \cdot d$.

The oxygen requirements, Or (kg O_2/d), can be calculated by the following formula:

$$\text{Or} = a\eta L + bZ,$$

where L is the BOD load (kg BOD_7/d); η is the treatment efficiency; Z is the amount of mixed liquor suspended solids in the aeration tank (kg MLSS); $a = 0.005$, $b = 0.2$ if $L_z > 0.2$; and $b = 0.1$ if $L_z < 0.1$; $L_z = L \cdot Z^{-1}$ (kg BOD_7/kg MLSS·d). The oxygen requirement allow to calculate the oxygenation capacity of the aeration system.

The amount of air depends on the type of the aeratior used.

Usually aeration is accomplished by means of diffusers, since at northern lattitudes freezing can play havoc with surface aerators, but it does not affect bottom aeration equipment. In this case the need of air is proportional to the submerged depth (fig. 1). However, in order to ensure the sufficient circulation the amount of air should be at least 20-30 m^3/h per one meter of the tank length.

Special attention should be directed to the dimensioning of compressors. The selection of their size should allow to graduate the air according to the load. One compressor must always serve as reserve unit. In the case of the activated sludge process the minimum pressure of compressors is 10-15 kPa, but for the simultaneous precipitation it should be 15-20 kPa higher than the pressure of the submersed depth.

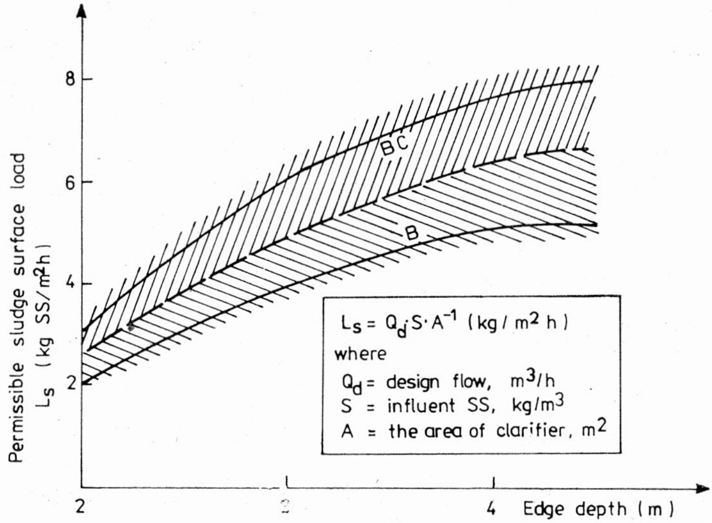

Fig. 1. The permissible surface loading as a function of the biological (B) and biological-chemical (BC) sludge [1]

Rys. 1. Dopuszczalne powierzchniowe obciążenie osadnika dla osadów z biologicznego oczyszczania (B) oraz osadów z biologiczno-chemicznego oczyszczania (BC) [1]

The level of noise in the compressor room should be below 100 dB, and lower than 85 dB in the surrounding room. The maximum air velocity in various piping parts should be as follows: 5 m/s in the beginning, (10 m/s at the end) of the stem pipe, and 20 m/s in the aeration pipe.

2.2. PHOSPHORUS REMOVAL BY PRECIPITATION

Biological treatment by activated sludge method (fig. 2a) removes only a small fraction of the phosphorus contained in municipal wastewaters. In some cases, when removal requirements are higher than those with respect to organic matter, the direct precipitation method is used (fig. 2d). The precipitants (aluminium sulphate, lime or ferrous salts) are added to a flocculation tank which is followed by a clarifier. In this method BOD and phosphorus removal may amount to about 60% and 80-90%, respectively. If, however, a high percent of the phosphorus removal is required, the postprecipitation method is normally applied, in which biological treatment is followed by chemical treatment (fig. 2b). In this case, the precipitants (such as aluminium sulphate or lime) are also added to a flocculation tank, where the dissolved and suspended forms of phosphorus are flocculated. The total phosphorus reduction may be as high as 90-95%, and the BOD reduction may reach 95%.

A high phosphorus reduction, ranging from 85 to 90% (BOD reduction 90-95%) may be also achieved by the least costly simultaneous precipitation method (fig. 2c). It is the most widely applied method in the Finnish activated sludge plants, where the precipitants (ferrous salts) are added directly to the aeration tanks. Normally ferrous sulphate is used as a precipitant since it is rather a cheap waste material. This method is also employed in some other countries in Europe, but as precipitants ferrichloride or aluminium sulphate are used.

Ferrous sulphate should be fed either to the aeration tank influent or directly to the aeration tank, where the ion is oxidized. While feeding this precipitant, a sufficient circulation must be maintained in the tank (especially when the plant is overloaded) to assure the oxidation of the iron and prevent the clogging of diffusers. Since the ferrous sulphate feeding effects the sludge settling properties, the sludge index (of a half of hour) should be maintained above 100.

Aluminium sulphate should be fed into the end part of the aeration tank, where the flocks have no time to spread. In some cases, it is fed also to the separate flocculation basin and in this case the method seems to be intermediate between the simultaneous and the direct precipitation.

In the method of simultaneous precipitation lime cannot be used because of its high alkalinity deteriorating the activity of the activated sludge.

The method of simultaneous precipitation can be applied in the existing treatment plants without their reconstruction, the only additional elements being the storage and solution tanks for ferrous sulphate. The solution of ferrous sulphate is very corrosive for

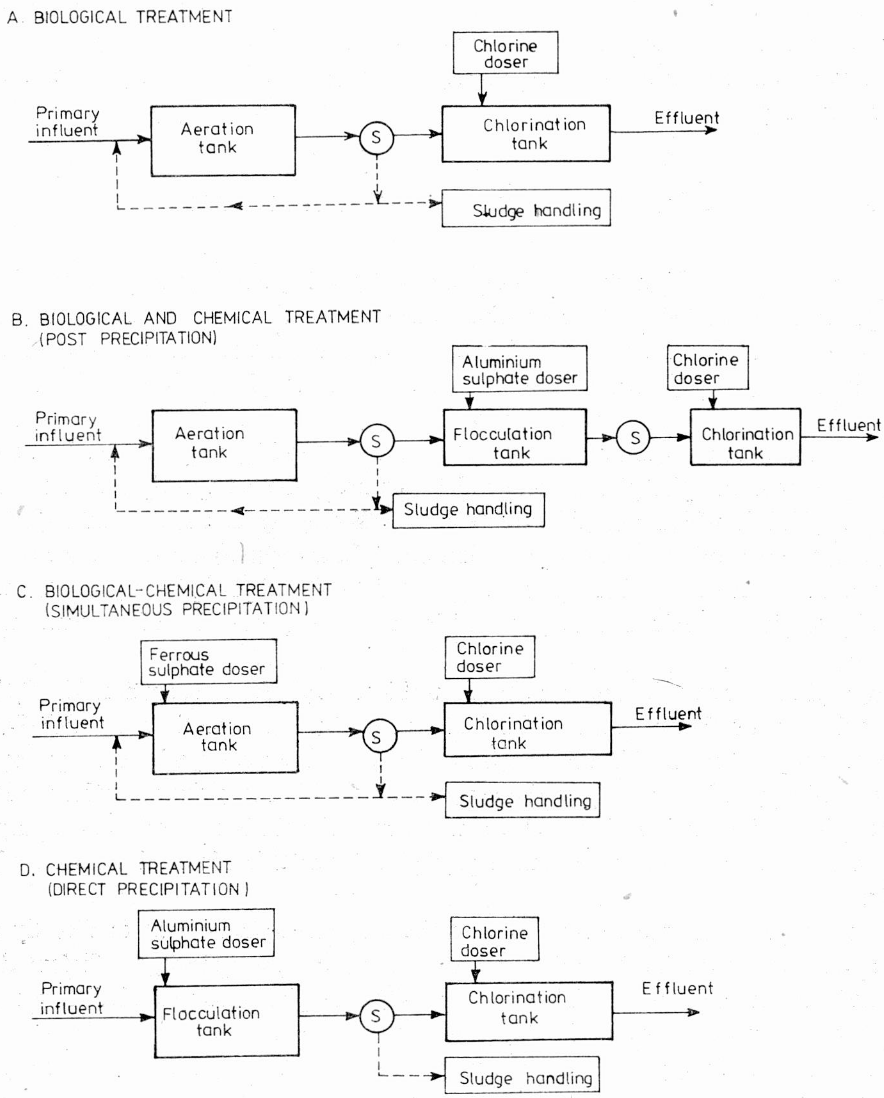

Fig. 2. Various municipal wastewater treatment schemes
Rys. 2. Schematy technologiczne oczyszczalni ścieków miejskich

metals that is why these tanks should be built from plastics and acidfast steel. Since ferrous sulphate (in crystalline or solution form) highly irritates skin and its vapours seem to irritate respiratory organs, the basins have to be kept covered, and the solution prepared by means of mechanical mixers. The time of the personnel staying in the storage or dissolving room should be reduced to minimum, and even then respiratory protectors should be used.

Ferrous sulphate is normally applied in form of 20-30% solution, but in small plants dry doses can also be daily added. The concentration is determined by the specific gravity test.

The requirements of various coagulants for phosphorus removal from municipal wastewaters are given in tab. 1.

Table 1

Requirement for precipitants used in phosphorus removal from municipal wastewaters [1]
Zapotrzebowanie na środki strącające stosowane do usuwania fosforu ze ścieków komunalnych [1]

Precipitant	Requirement, g/m³	
	Average	Range
$Ca(OH)_2$	400	300-1200
$FeSO_4 \cdot 7H_2O$	100	80- 200
$FeCl_3$	70	50- 150
Finnferii*	190	130- 400
$Ca(OH)_2$ + $FeSO_4 \cdot 7H_2O$	200+150	150-300+100-200
$Al_2(SO_4)_3 \cdot 14H_2O$	120	80-150

* Solution of ferrichloride and ferrous sulphate.

2.3. SEDIMENTATION

In the design of clarifiers the surface load was the chief parameter. The permissible surface loading rate of the clarifiers depends mainly on their function in the assumed treatment method (primary, intermediate or secondary clarification). The surface loading rates and detention times for various types of clarifiers used in Finland are given in tab. 2. The values approaching the lower limit are normally recommended.

The sludge surface loads of clarifiers should also be taken into account, especially in activated sludge plants. These loads are the determining factors when the sludge contents are high and the basin depth is low. The value of the permissible sludge load (fig. 3) depends on the type of sludge, the sludge settling characteristics, the depth of basin, and the hydraulic surface load.

Basins with the edge depth below 2.5 m are not recommended for the clarification in the activated sludge method. The following values of the flow rate have been taken for connection with checking of dimensioning: 0.25-0.35 m/s for the biological process and 0.1-0.2 m/s for the chemical process. The edge load of the overflow gutters (total length of the edges) should not exceed 20 $m^3/m \cdot h$ for the primary clarification and 10 $m^3/m \cdot h$ for intermediate and post clarification.

The preliminary treatment of wastewaters prior to that of activated sludge includes usually clarification, but additional processes, such as screening, sand trapping, and pH-monitoring are also used.

Table 2

Permissible surface loadings and recommended detention times for different types of sedimentation tanks [1]
Dopuszczalne obciążenia powierzchniowe i zalecany czas przetrzymywania dla różnych typów osadników [1]

Type of sedimentation tank	Surface loading m/h	Detention time h
Primary sedimentation for biological or chemical plants		
S_1	1.5-3	1.3-0.7
S_2	2-4	1.7-0.9
S_3	1.5-3	1.3-0.7
S_4	2-4	
Intermediate sedimentation for post precipitation		
S_1	0.8-1.0	2.5-2.3
S_2	1.2-1.4	2.8-2.6
S_3	0.7-0.9	2.6-2.4
S_4	1.2-1.4	
Secondary sedimentation for simultaneous precipitation or post precipitation		
S_1	0.7-0.9	3.2-2.8
S_2	1.0-1.2	3.5-2.9
S_3	0.6-0.8	3.3-2.9
S_4	1.2-1.4	
Sedimentation for direct precipitation		
S_1	0.7-1.1	3.3-2.1
S_2	1.0-1.5	3.5-1.9
S_3	0.6-1.0	3.3-2.1
S_4	1.0-1.5	

S_1 – rectangular tank, horizontal sedimentation.
S_2 – rectangular tank, horizontal/vertical sedimentation.
S_3 – round tank, horizontal sedimentation.
S_4 – dortmund-tank (round or square), vertical sedimentation.

2.4. CHLORINATION

In Finland the chlorination of treated municipal wastewaters is compulsory at least during the swimming season.

Chlorine is used in the following forms: the chlorine gas which is delivered as a liquid in steel vessels; the natrium hypochlorite (water solution containing 10% of active chloride)

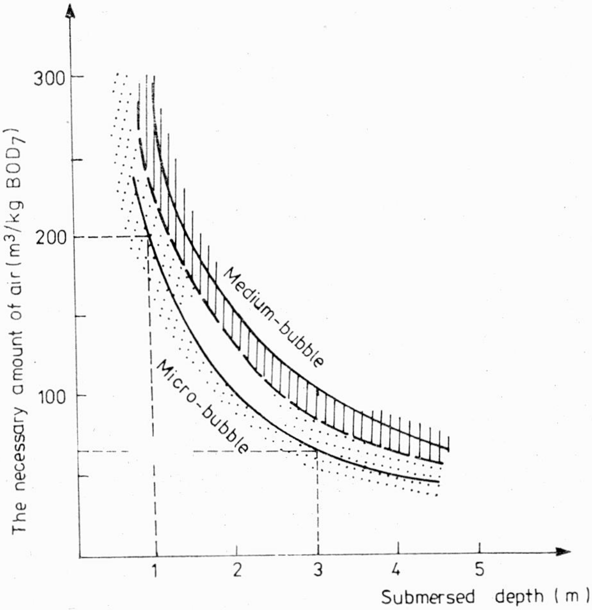

Fig. 3. The approximate necessary amount of air supplied by diffusers [1]

Rys. 3. Przybliżona ilość koniecznego powietrza doprowadzonego za pomocą dyfuzorów [1]

delivered in plastic tanks; and solid chlorine compounds, most commonly calcium hypochlorite (with about 70% of activated chlorine), which is available in granular form.

The use of chlorine gas is restricted due to its poisonous effects — it irritates eyes, mucous membranes of mouth, throat and respiratory organs. Therefore, in small treatment plants only natrium hypochlorite and calcium hypochlorite granules are applied for disinfection. For the wastewater disinfection the dose of chlorine is about 10-30 mg/dm^{-3}, in water treatment the dosage ranges within 5–10 mg/dm^{-3}. In the design of the chlorination process for the small plants, account should be taken of the fact that the reaction time of natrium hypochlorite is of about 20–30 min. The recommended ventilation in the chlorine storage and chlorine apparatus room should be 30–60× room volume per hour.

2.5. SLUDGE HANDLING

Due to the chemical treatment the amount of sludge has increased so greately that its removal to a dumping area is no solution nowadays. However, in Finland about 75% of the sludge is still removed to the dumping area. The sludge handling may consist of thickening, stabilization, dewatering and storage. The amounts of sludge obtained from different treatment methods, as used in dimensioning of sludge handling equipment, are given in tab. 3.

The thickening of sludge can be applied before and/or after its stabilization. The dry matter contents increase usually two or threefold in the thickening process. The thickener loading depends mainly on the type of sludge, and it is recommended to be used as follows: 100–150 kg $TS/m^2 \cdot d$ for mechanical sludges; 25–30 kg $TS/m^2 \cdot d$ for biological sludges, 30–50 kg $TS/m^2 \cdot d$ for mixed mechanical and biological sludges; and 80–150 kg $TS/m^2 \cdot d$ for chemical sludges.

The sludge stabilization processes used are: aerobic digestion (where organics are dissolved aerobically), anaerobic digestion (where organics are dissolved anaerobically), and the lime treatment (where lime is mixed with the sludge).

The detention time required for the aerobic digestion depends on the sludge quantity and the temperature and it lasts for 20–30 days in Finland, depending on the place. The oxygen demand in this process ranges from 1.2 to 1.8 kg O_2/kg VSS. The average contents of organic dry matter in chemical sludges is about 50–60%, and 60–80% in other sludges. In the anaerobic digestion the necessary tank volume is determined by the shape of digestion

Table 3

Quantity and quality of sludge from various treatment systems [1]
Ilość i jakość osadu ściekowego przy różnych systemach oczyszczania [1]

Treatment system	Dry matter, TS		Quantity of sludge	Content of dry matter
	g/m^3	g/PE·d	dm^3/PE·d	%
Primary treatment	150	60	1.0-2.0	3.0-6.0
Biological treatment				
excess sludge in conventional activated sludge	90	35	1.0-3.0	0.5-3.0
conventional activated sludge without primary sedimentation	240	95	2.5-5.0	1.0-4.0
extended aeration or first-stage digestion	160	65	1.5-3.0	1.0-4.0
Simultaneous precipitation				
conventional activated sludge	320	130	2.5-5.0	1.5-5.0
extended aeration	240	95	2.0-4.0	1.0-4.0
Chemical precipitation				
chemical sedimentation with $Ca(OH)_2$, 300 g/m^3	600	240	2.5-6.0	4.0-10.0
direct precipitation: with				
$Al_2(SO_4)_3$, 125 g/m^3,	70	30	1.0-3.0	1.0-3.0
with $FeCl_3$, 70 g/m^3	100	40	1.0-3.0	1.5-4.5
post precipitation with $Al_2(SO_4)_3$, 125 g/m^3	60	25	1.0-2.5	1.0-2.0

tank and the method of mixing. The tank volume can be calculated in different ways. Normal digestion time ranges between 25–30 days. The digestion can be designed as two-tank operation. Mixing and heating take place in the first tank, while in the second one only heating occurs.

The lime used in treatment increased pH of sludge, exceeding the value of 11, due to hydratation to $Ca(OH)_2$. This high pH, being maintained for 2 weeks, results in inhibition of microbial growth. Lime applied to dried sludge increases the temperature and in this case the microbial growth is inhibited due to pasteurization process. The stabilization of sludge with lime and the digestion are the methods most appropriate for small municipal wastewater treatment plants.

3. DESCRIPTIONS OF SELECTED SMALL TREATMENT PLANTS

3.1. VALMET PLANTS

The Valmet sewage treatment plants are built by using standardized prefabricated modules of steel plates and glass fibres. Usually this type of treatment plant consists of the following main parts: communitor or screen, sand trap (in necessary), aeration tanks with aeration system, sludge stabilization tanks, sedimentation basins, air compressors and necessary sewage, air and sludge piping systems.

The aeration tanks are made from steel plate (5 mm, 37 B) elements, coated with inert polimer epoxy (min. 270 μm), while the sedimentation basins are constructed of reinforced plastic (fig. 4). The overflow gutter is also made of reinforced plastic, PVC (or polyethylene) being used for sewage and air pipes (only the main compressed air piping as well as sludge pipes are made of steel). The dampling ring is produced of aluminium. The application of the above materials lowers the weight of the plant (the heaviest part weighs 390 kg). The modules are also connected by galvanized nuts and bolts using jointing lists made of neoprene, so no welding on side is necessary.

The aeration system for mixed liquor in aeration tanks and for sludge stabilization in stabilization tanks consists of Nokia's polyethylene tube diffusers (type KP) of different porosities, enabling to choose the right bubble size for a given treatment process. The compressor is the only movable part of the treatment plant. Usually a model of Aerzener type GMa 11.3, equipped with a motor 5.5 kW, 2 560 r/min is recommended, and two air compressors (one standby) are used. The pumping system of the plant consists of air lift pumps (⌀ 63 mm), made of plastic. The plants produced range from 50 P.E. to about 8 000 P.E.

3. 2. HKN PLANTS

Another example of a small plant for industrial wastewater treatment produced in Finland is the HKN plant. This type of plant is mainly constructed for dairies, slaughter houses, foodstatts industry, breweries, but it may also be used in small communities and motels.

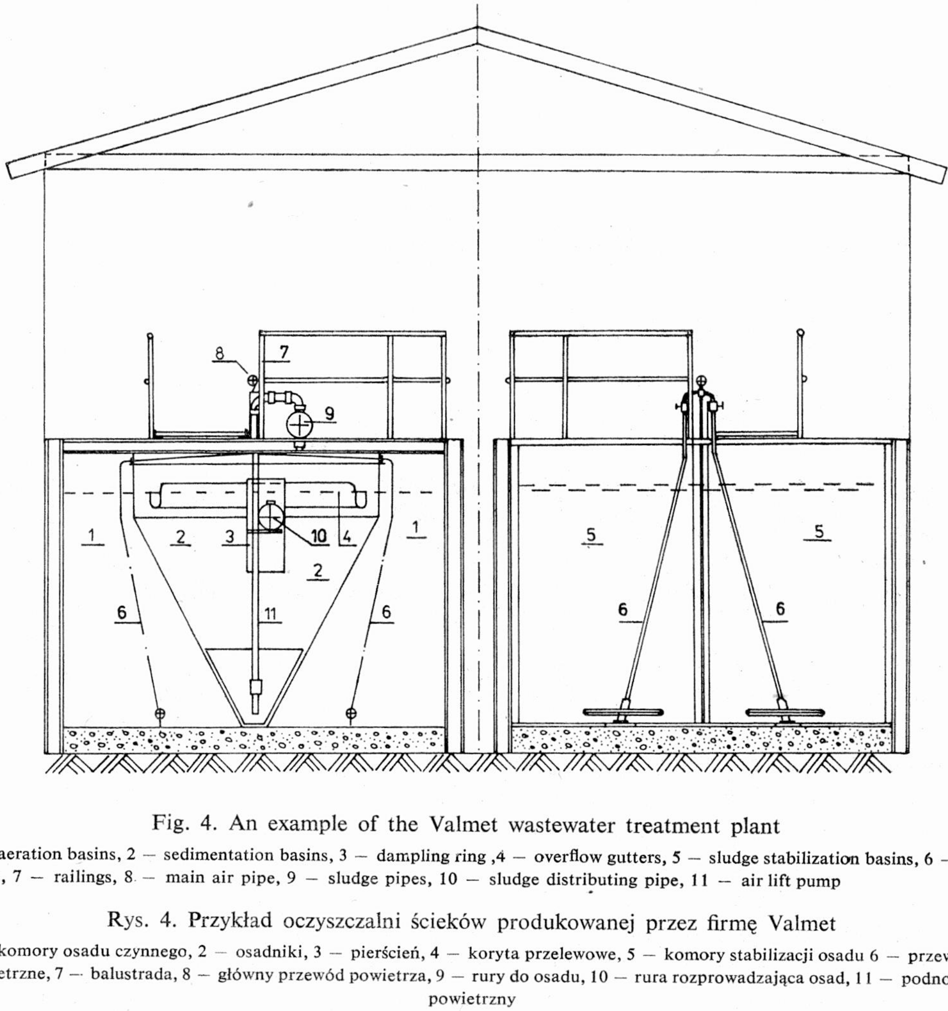

Fig. 4. An example of the Valmet wastewater treatment plant

1 – aeration basins, 2 – sedimentation basins, 3 – dampling ring, 4 – overflow gutters, 5 – sludge stabilization basins, 6 – air pipes, 7 – railings, 8 – main air pipe, 9 – sludge pipes, 10 – sludge distributing pipe, 11 – air lift pump

Rys. 4. Przykład oczyszczalni ścieków produkowanej przez firmę Valmet

1 – komory osadu czynnego, 2 – osadniki, 3 – pierścień, 4 – koryta przelewowe, 5 – komory stabilizacji osadu 6 – przewody powietrzne, 7 – balustrada, 8 – główny przewód powietrza, 9 – rury do osadu, 10 – rura rozprowadzająca osad, 11 – podnośnik powietrzny

The HKN plant operates on a batch type extended aeration principle. The aeration and the decanting occur in the same tank (fig. 5) from which the effluent is evacuated by a floating type pipe. The total operation time amounts to 24 h and consists of three phases: aeration (20 h), sedimentation (3 h), and emptying (1h). These phases are controlled automatically.

In aeration basin made of concrete a bottom aeration system is used. The submerged parts of this system are made of stainless steel. The pumping well and the machine station well make a common whole with the following important parts: pumps with comminuting edges, a compressor, ready pipe couplings, an electric centre with wire connections, an automatic effluent valve, electric centre with wire connections, a protection cover construc-

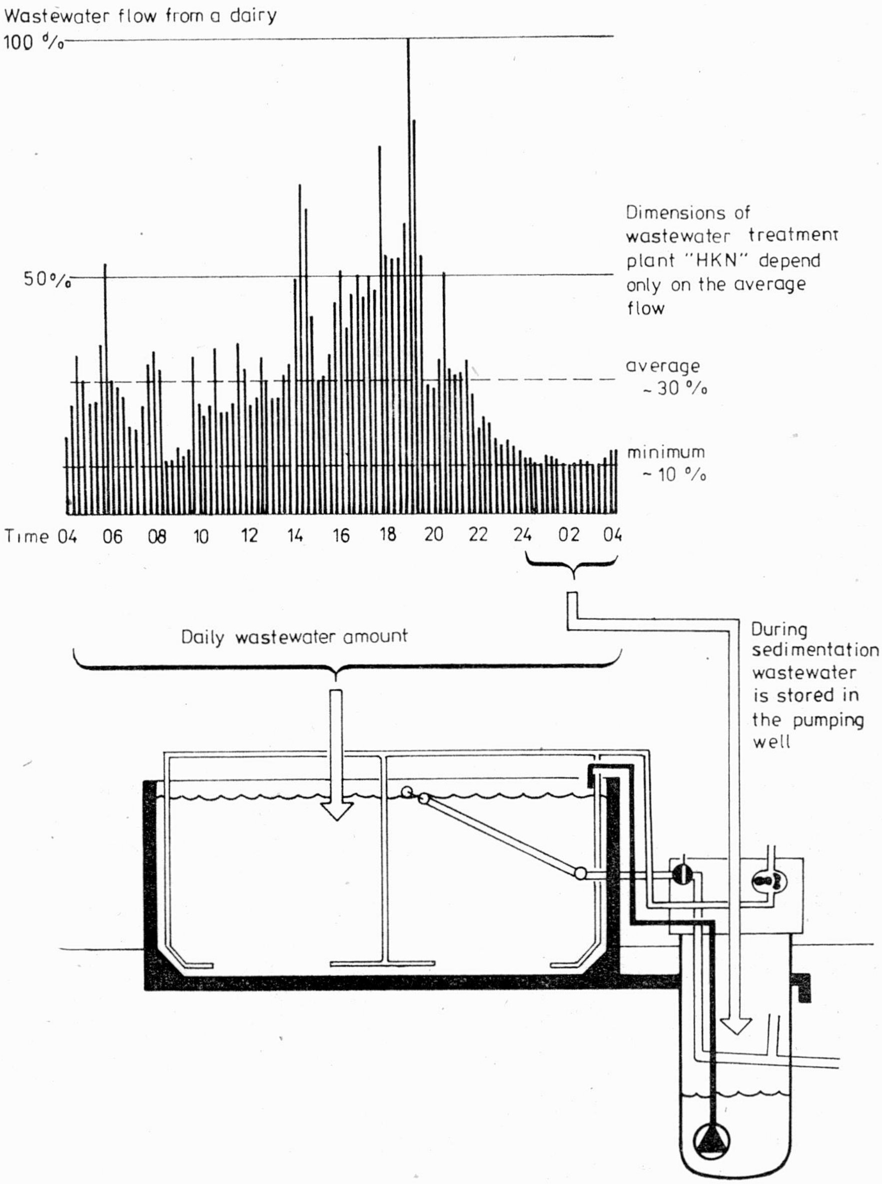

Fig 5. The operation of the HKN wastewater treatment plant [7]
Rys. 5. Schemat działania oczyszczalni ścieków typu HKN [7]

tion of aluminium – plate with steel reinforcements and sound insulations. The pumping well and the main parts of the piping are made of stainless steel, while the interstructures of epoxy painted carbon steel. Various types of the HKN plant cover the load ranging from 25 to 500 kg BOD_5/d.

4. EXAMPLES OF APPLICATION AND PERFORMANCE RESULTS

The examples of the application of selected types of the package treatment plants are presented for illustrative purposes only.

The Valmet municipal wastewater treatment plants have operated at very low temperatures, in various countries, primarily in Norway and Finland. The results of performance in terms of suspended solids, BOD_7, COD and phosphorus reduction are given in tab. 4 for various types of the Valmet plants ranging from 250 P. E. to 4 000 P. E. and operating under different conditions.

Table 4

Performance of various types of Valmet sewage treatment plants
Wydajność różnych oczyszczalni typu Valmeta

Treatment plants / Parameter	Vålve, Norway 250 PE Post precipitation	Sel, Norway 500 PE Simult. precipitation	Stange Norway 500 PE Post precipitation	Svelvik, Norway 1400 PE Biological	Muchos, Finland 4000 PE Simult. precipitation
Date of sampling	23.1.76	13.12.76	6.9.76	20.1.76	21.6.77
Influent					
Flow, m^3/h^{-1}	0.5	3.0	10.8	17.0	87.0
Temperature, °C	7.5	6.6	12.6	8.0	7.0
pH	8.7	6.6	7.7	8.4	7.5
Suspended solids, mg/dm^{-3}	275.0	685.0	680.0	160.0	178.0
BOD_7, mg/dm^{-3}	235.0	n.r.*	n.r.*	265.0	197.0
COD, mg/dm^{-3}	400.0	965.0	1370.0	438.0	n.r.*
Total P, mg/dm^{-3}	12.5	11.4	27.9	n.r.*	9.5
Orto P, mg/dm^{-3}	n.r.*	9.1	21.6	n.r.*	n.r.*
Effluent					
Suspended solids, mg/dm^{-3}	7.0	65.0	27.0	40.0	54.0
BOD_7, mg/dm^3	6.0	8.0	2.0	5.0	7.0
COD, mg/dm^{-3}	38.0	45.0	30.0	92.0	n.r.*
Total P, mg/dm^{-3}	0.3	0.8	3.2	n.r.*	2.2
Orto P, mg/dm^{-3}	0.1	0.06	2.5	n.r.*	n.r.*
Reduction					
Suspended solids, %	97.5	90.5	99.0	75.0	71.1
BOD_7, %	97.4				96.4
COD, %	90.5	95.3	97.0	98.1	
Total P, %	97.6	93.0	88.5	79.0	76.8
Orto P, %		99.3	88.4		
Chemical dosage, g/m^3 and chemical used	150 $Al_2(SO_4)_3$	65 $Al_2(SO_4)_3$	190 $Al_2(SO_4)_3$	—	150 $FeSO_4$
Organic load in aeration tank, g/g MlSS • d	0.04 (BOD_7)	0.2 (COD)		0.3 (BOD_7)	0.16 (BOD_7)
Reference	2	3	4	2	5

* not reported.

An example of the Valmet simultaneous precipitation plant (with ferrous sulphate) is the plant of Martilla, in Finland for 1 000 P.E. It was designed for the wastewater flow of 24 m^3/h (maximal flow 48 m^3/h) and the load of 75 kg BOD_7/d. The main elements of the plant are the following: screens, two aeration tanks with clarification, and sludge stabilization basins. In dimensioning of each aeration tank of the volume of 80 m^3 the following parameters have been assumed: the sludge load (0.19 kg BOD_7/kg MLSS·d), the volume load (0.94 kg BOD_7/kg MLSS·d), the aeration time (3.3 h), and the mixed liquor suspended solids (MLSS) (5 kg/m^3). Aerobic sludge stabilization proceeded in basins of the volume of about 54.5 m^3, stabilization time amounting to 25 days. The results of the operation of this plant during the winter, 1979 are given in tab. 5.

A biological treatment plant produced by Valmet was also delivered to Poland for Zakopane winter sport centre in spring 1976, and started to operate in January 1977. The plant for 4 000 P. E. consists of two parallel units, its dimensioning was based on the following parameters: wastewater flow — 64 m^3/h and the load — 200 kg BOD_5/d. The clarifiers (made of reinforced plastics) were designed for the surface load of 0.87 m/ h

Table 5

Performance of simultaneous precipitation* of Valmet sewage treatment plant (1000 P.E.) in community of Marttila, Filand, during winter conditions [6]

Metoda jednoczesnego strącania w oczyszczalni typu Valmeta (1000 P.E.) w warunkach zimowych, Marttila, Finlandia

Parameter	Date of sampling				
	9. 1. 79	30. 1. 79	2. 2. 79	26. 2. 79	28. 2. 79
Influent					
Flow, m^3/d^{-1}	50.0	65.0	69.0	58.0	59.0
pH	7.1	6.8	7.0	7.5	7.6
Suspended solids, mg/dm^{-3}	560.0	820.0	390.0	440.0	160.0
BOD_7, mg/dm^{-3}	350.0	360.0	210.0	380.0	210.0
Perm. value	n.r.**	220.0	120.0	180.0	76.0
Total P, mg/dm^{-3}	14.0	19.9	15.8	15.3	11.6
Total N, mg/dm^{-3}	64.0	102.0	74.0	101.0	69.0
Effluent					
BOD_7, mg/dm^{-3}	11.0	19.0	15.0	27.0	28.0
Perm. value	n.r.**	20.0	17.0	16.0	17.0
Suspended solids, mg/dm^{-3}	16.0	24.0	22.0	15.0	20.0
Total P, mg/dm^{-3}	0.68	1.03	0.87	0.81	0.91
Soluble P, mg/dm^{-3}	0.38	n.r.**	n.r.**	n.r.**	n.r.**
Total N, mg/dm^{-3}	43.0	61.0	56.0	54.0	54.0
Reduction					
BOD_7, %	97	95	93	93	87
Suspended solids, %	97	97	94	97	88
Total P, %	95	95	94	95	92
Total N, %	33	40	24	47	22

* 100 g $FeSO_4 \cdot 7\ H_2O/m^3$; avg. air temp. — 25°C; avg. temp. in aeration tank +5°C.
** not reported.

The surface area of each was 74 m^2, and the volume — 122 m^3. In dimensioning of aeration basin the following values were assumed: the sludge load — 0.22 kg BOD$_5$/kg MLSS·d, the organic volumetric load — 1.08 kg BOD$_5$/m^2·d, the mixed liquor suspended solids — 5 kg/m^3, and the aeration period — 2.9 h. The aeration basins, of the volume of 184.4 m^3, are made of steel, painted with epoxy resin paint. The average BOD$_5$ removal during the winter 1977 was about 83%, ranging from 65% to 98.5%.

The performance of the HKN treatment plant for a dairy in Luumäki, Finland, is illustrated graphically in fig. 6.

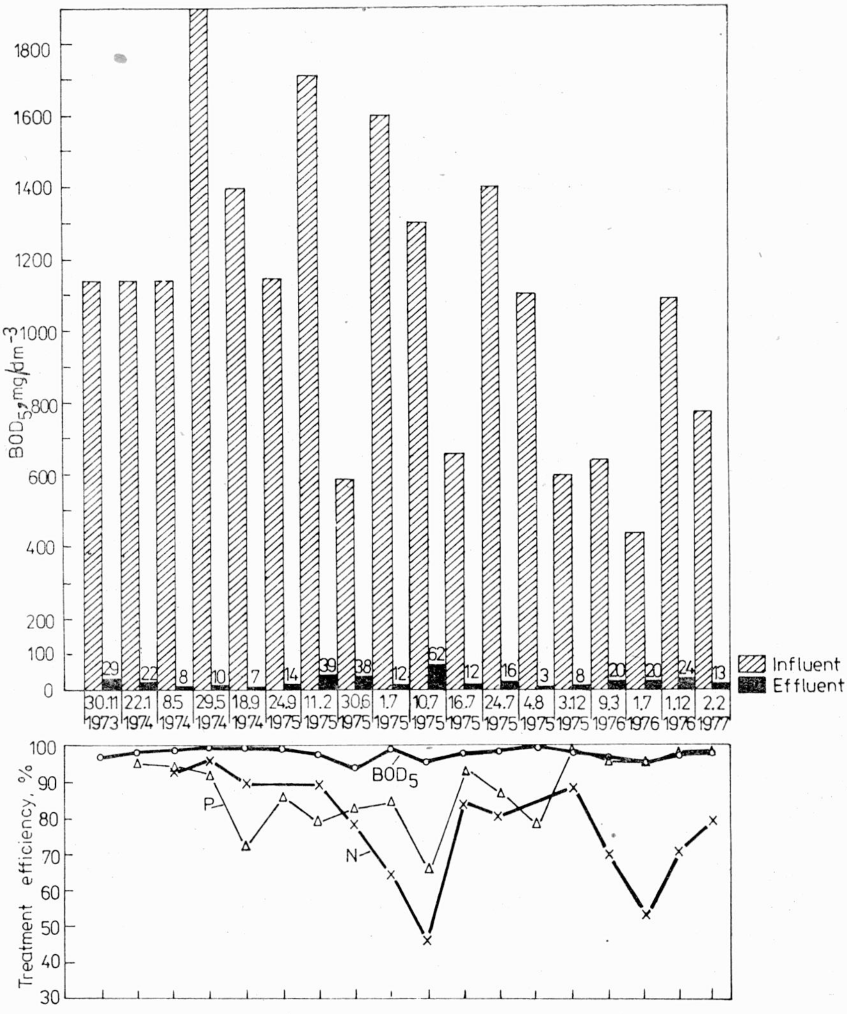

Fig 6. Performance results of the HKN plant for dairy wastewater treatment at Luumäki, Finland [7]
Rys. 6. Wyniki działania oczyszczalni typu HKN oczyszczającej ścieki mleczarskie w Luumäki, Finlandia [7]

5. SUMMARY AND CONCLUSIONS

The basis for design of small treatment plants is presented. These plants are designed to meet not only the requirements for organics removal, but also for the removal of phosphorus, which can cause an excessive growth of algae in lakes or streams.

The serial production of standardized prefabricated modules for wastewater treatment plants lowers significantly the cost of production. The modular design allows to construct treatment plants, based on different operational schemes, and to enlarge economically the existing area by using the same modules. Since the modules are connected by galvanized nuts and bolts there is also no need for one-site welding.

While constructing treatment plants attention should be paid to the use of proper corrosion-resistant materials or to their protection against corrosive action. The application of reinforced plastics and steel plates coated with epoxy, plastic air lift pumps, PVC or polyethylene pipes, and aluminium damping rings lowers significantly the plant weight.

The performance of these plants should not be considered as only a seasonal, but as a whole year operation. In cold northern climates, as in Findland and in countries such as Poland where cold winters frequently occur, freezing is an important factor to be considered in design of treatment facilities. In such climates advisable small treatment plants on the ground and/or house them to protect against heat loss. In Finland about 90 % of these plants is covered, and many of them are heated. The selection of the bottom aeration system in the form of plastic diffusers with compressed air decreases the possibilities of equipment freezing. Energy consumption of this diffuser is low. It is also important that the compressor is the only moving part in these systems. Spray from mechanical aeration systems can cause the formation of ice on aerators, and even complete freezing can occur if there is a power failure. Surface areators can also disturbe the structure of flocks in small aeration basins.

Poor treatment results are mostly due to maintenance, since the performance of a treatment plant is as good as the maintenance of the system.

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PODSTAWY PROJEKTOWANIA I DZIAŁANIA MAŁYCH OCZYSZCZALNI ŚCIEKÓW USUWAJĄCYCH ZWIĄZKI ORGANICZNE ORAZ FOSFOR PRZY NISKICH TEMPERATURACH – DOŚWIADCZENIA FIŃSKIE

W pracy omówiono zasady projektowania małych oczyszczalni ścieków usuwających związki organiczne oraz fosfor i działających na terenach o surowych warunkach klimatycznych.

Przedstawiono wybrane typy małych oczyszczalni ścieków miejskich i przemysłowych produkowanych w Finlandii oraz podano przykłady zastosowań wraz z wynikami ich działania.

Zwrócono uwagę na korzyści wynikające z wprowadzenia modularnych rozwiązań prefabrykowanych, konieczność stosowania właściwych materiałów i zabezpieczenia prawidłowego działania oczyszczalni w warunkach zimowych oraz właściwą eksploatację.

ENTWURFSGRUNDLAGEN FÜR KLEINE ARA MIT PHOSPHORBESITIGUNG BEI NIEDRIGEN TEMPERATUREN – FINNISCHE ERFAHRUNGEN

Der Bericht legt die Entwurfsgrundlagen für kleine Abwasserreinigungsanlagen (ARA), die bis zur Beseitigung des Phosphors hineinreichen und unter harten Klimaverhältnissen arbeiten, dar.

Beschrieben werden ausgewählte Typen kleiner ARA die in Finnland für häusliche und industrielle Abwässer hergestellt werden. Angeführt werden Beispiele samt Wirkung solcher Anlagen.

Den Vorteilen der Einführung von vorgefertigten Elementen in Modularausführungen, der Notwendigkeit des Einsatzes von entsprechendem Material und dem Sicherstellen des regelrechten Betriebs dieser ARA im Winter wurde besondere Aufmerksamkeit geschenkt.

ОСНОВЫ ПРОЕКТИРОВАНИЯ И ДЕЙСТВИЯ НЕБОЛЬШИХ СТАНЦИЙ ОЧИСТКИ СТОЧНЫХ ВОД, УДАЛЯЮЩИХ ОРГАНИЧЕСКИЕ СОЕДИНЕНИЯ И ФОСФОР, ПРИ НИЗКИХ ТЕМПЕРАТУРАХ – ФИНСКИЙ ОПЫТ

В работе обсуждены принципы проектирования небольших станций очистки сточных вод, удаляющих органические соединения, а также фосфор, и действующих на территориях с суровыми климатическим условиями.

Представлены избранные типы небольших станций очистки городских и промышленных сточных вод, построенных в Финляндии, а также приведены примеры применений совместно с результатами их действия.

Уделено внимание выгодам, вытекающим из введения модулярных сборных решений, необходимости применения соответственных материалов и обеспечения правильного действия очистной станции в зимних условиях, а также правильной эксплуатации.