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THE METHODS OF PHOSPHORUS REMOVAL BY BIOLOGICAL PROCESSES

BY

VALENTIN-VASILE CREŢU

Biological phosphorus removal is a developed technique of designing suspended growth activated sludge systems to remove soluble phosphorus from waste-water. There are six variations of this phenomenon. These alternative are: Phostrip process; Modified Bardenpho process; A/O process; UCT (University of Capetown) process; Sequencing Batch Reactor (SBR) process; Operationally modified activated sludge. The selection procedure must consider all aspects of the phosphorus removal process including its impact on plant performance, operations and maintenance.

Important factors are: a) degree of phosphorus removal required; b) size of plant; c) impact on sludge handling; d) permanent or temporary nature of phosphorus removal requirement; e) total cost and f) impact on operation and maintenance.

1. Introduction

Conventional secondary biological treatment systems accomplish phosphorus removal by using phosphorus for biomass synthesis during BOD removal.

Phosphorus is an important element in microorganisms for energy transfer and for such cell components as phospholipids, nucleotides, and nucleic acids.

A typical phosphorus content of microbial solids is 1.5...2% based on dry weight. Wasting of excess biological solids with this phosphorus content may result in a total phosphorus removal of 10...30%, depending on the BOD-to-phosphorus ratio, the system sludge age, sludge handling technique, and side stream return flows.

2. Biological Phosphorus Removal Mechanism

The generally accepted theory for biological phosphorus removal is that anaerobic – aerobic contacting results in a competitive substrat utilization and selection of phosphorus-storing microoeganisms.

An understanding of the step involved in the biological phosphorus removal mechanism provides a useful insight into the factors that can affect the performance of biological phosphorus removal systems [1], [2].

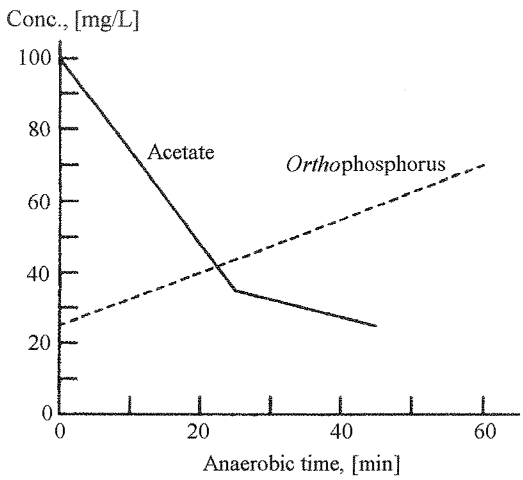

Fig. 1.– Acetate assimilation and phosphorus release *vs.* anaerobic time.

The organism associated with phosphorus removal belonged to the *Acinetobacter* genus. These bacteria are short, plump, gram-negative rods with a size of 1...1.5 μm. The anaerobic phase in excess phosphorus removal systems was important for production of simple carbohydrates such as ethanol, acetate, and succinate, which serve as carbon sources for *Acinetobacter*. A significant phosphorus release rate could be promoted by the addition of carbon dioxide during the anaerobic phase, which also lowered the pH.

The removal of phosphorus in a system containing *Acinetobacter* became significant only after the development of an *Aeromonas* population. The *Aeromonas* bacteria served the important function of producing fermentation products in the anaerobic phase for the *Acinetobacter*. These species of bacteria and a species of *Acinetobacter* accomplished denitrification in anoxic zones of biological nitrogen removal systems.

The concentration of a soluble readily biodegradable substrate can be determined from the increase in the oxygen uptake rate measurements of a batch activated sludge sample after the addition of influent. Fig. 1 shows the decrease in acetate concentration and increase in *ortho*phosphate concentration as a function of the anaerobic time. The molar ration of acetate utilisation to phosphorus release was 1.3.

The understanding of the biological phosphorus removal mechanism was significantly advanced with the observations on storage of carbohydrate products within biological cells in the anaerobic zone and phosphorus-containing volutin granules in the aerobic zone. The most commonly reported anaerobic intracellular storage product has been polyhydroxybutyrate (PHB) [3], [5].

The proposed biological phosphorus removal mechanism is summarized in Fig. 2. Acetate and other fermentation products are produced from fermentation reactions by normally-occurring facultative organisms in the anaerobic zone.

A generally accepted concept is that these fermentation products are derived from the soluble portion of the influent BOD and that there is not sufficient time for the hydrolysis and conversion of the influent particulate BOD.

The fermentation products are preferred and readily assimilated and stored by the microorganisms capable of excess biological phosphorus removal. This assimilation and storage is aided by the energy made available from the hydrolysis of the stored polyphosphates during the anaerobic period. The stored polyphosphate provides energy for active transport of substrate and for formation of acetoacetate, which is converted to PHB.

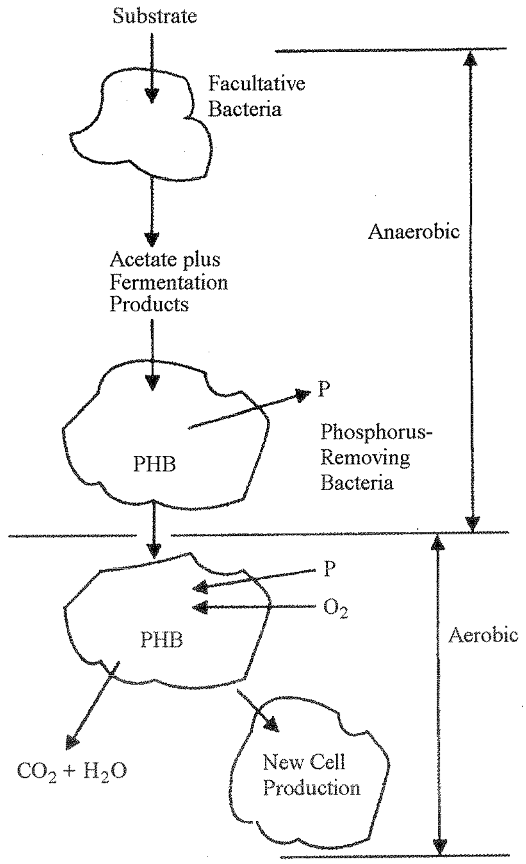

Fig. 2.– Schematic of biological phosphorus removal mechanism.

The fact that phosphorus-removing micro-organisms can assimilate the fermentation products in the anaerobic phase means that they have a competitive advantage compared to other normally-occurring microorganisms in activated sludge systems [4].

There are three commercial biological phosphorus removal processes: the Phostrip process, the modified Bardenpho process and the A/O process. But, other options used are the UCT process, sequencing batch reactors (SBRs), and operationally modified activated sludge systems.

3. Design Methodology

3.1. Phostrip Process

The major design considerations for the Phostrip process are the size of the stripper and solids contact tanks and the lime feed rate.

The size of the solids contact tank will be a function of the stripper tank supernatant overflow rate. This will be determinated by the return sludge feed rate to the stripper, the degree of solids thickening achieved, and the elutriation rate if the elutriant is composed of an outside flow instead of recycled stripper sludge. Typical values for stripper and reactor-clarifier design are given in Table 1.

The stripper design procedure involves the following steps:

a) determine or select the amount of return sludge that will pass through the stripper;

b) select the stripper underflow sludge concentration;

c) select the stripper SDT;

d) calculate the volume of sludge necessary in the stripper;

e) using a solids flux analysis or appropriate solids loading, calculate the stripper area requirements;

f) determine the sludge depth in the stripper;

g) provide a selected supernatant water depth to obtain the total stripper side water depth.

The phosphorus removal efficiency was correlated with three main operating parameters: the amount of return sludge passing through the stripper relative to the plant flow, the stripper SDT, and the stripper supernatant flow. The correlation developed can be expressed as follows:

$$1.85 - \frac{\log(100 - E)}{2.11} = (\mathrm{SL} - D)^{1/2}(\mathrm{SU}), \tag{1}$$

where: E is the percent phosphorus removal; SL – return sludge passing through stripper tank (100 lb dry solids/mil. gal of system influent flow); D – SDT, hSU – stripper supernatant flow as ratio of influent flow.

Table 1

Typical Operating Conditions for Biological Phosphorus Removal Processes [6]

Phostrip		Modified Bardenpho	
Parameter	Value	Parameter	Value
AS System			
F/M, [kg TBOD/kg MLVSS/d]	0.5...1	F/M, [kg TBOD/kg MLVSS/d]	0.1...0.2
SRT, [days[2]]	1	SRT, [days[2]]	10...30
MLSS, [mg/L]	600...5,000	MLSS, [mg/L]	2,000...4,000
HRT, [h[3]]	1...10	HRT, [h[3]]	
		Anaerobic	1...2
		Anoxic 1	2...4
		Nitrification	4...12
		(Aerobic 1)	
		Anoxic 2	2...4
		Aerobic 2	0.5...1.0
A/O		A/O plus Nitrification	
Parameter	Value	Parameter	Value
AS System			
F/M, [kg TBOD/kg MLVSS/d]	0.2...0.7	F/M, [kg TBOD/kg MLVSS/d]	0.15...0.25
SRT, [days[2]]	2...6	SRT, [days[2]]	4...8
MLSS, [mg/L]	2,000...4,000	MLSS, [mg/L]	3,000...5,000
HRT, [h[3]]		HRT, [h[3]]	
Anaerobic	0.5...1.5	Anaerobic	0.5...1.5
Aerobic	1...3	Anoxic	0.5...1.0
		Nitrification	3.5...6.0
Phostrip Stripper			
Feed, [% of inf. flow]	20...30	Return Sludge, [% of inf. flow]	100
SDT, [h]	5...20	Int. Recycle, [% of inf. flow]	400
Sidewater Depth, [m]	6.1		
Elutriation Flow, [% of stripper feed flow]	50...100		
Underflow, [% of inf. flow]	10...20		
P Release, [g P/g VSS]	0.005...0.02		
Reactor-Clanfier			
Overflow Rate, [m³/m²/d]	48		
pH	9...9.5		
Lime Dosage, [mg/L]	100...300		
Phostrip Stripper			
Return Sludge, [% of inf. flow]	25...40	Return Sludge, [% of inf. flow]	20...50
		Int. Recycle, [% of inf. flow]	100...300

3.2. Nitrate Nitrogen Removal Design

Fig. 3 illustrates the two modes of denitrification operation used in biological phosphorus removal systems. Nitrified mixed liquor is recycled to a pre-denitrification zone in the Modified Bardenpho process and also in the A/O process when nitrification occurs. In this zone, the incoming substrate drives the denitrification reaction as the facultative organisms use nitrate - released oxygen as the electron acceptor in lieu of DO.

The Modified Bardenpho process has a second anoxic tank, or post-denitrification zone. In the second anoxic zone, the denitrification rate is driven by the endogenous respiration oxygen demand as the mixed liquor since the influent substrate is depleted after the nitrification step.

The design objectives for biological phosphorus removal systems incorporating denitrification are firstly to determine the amount of nitrate nitrogen entering the pre-denitrification and post-denitrification zones and then to determine the volume of the anoxic zones [7].

The first step in the design is the preparation of a mass balance to determine the amount of influent nitrogen that will be oxidized to nitrate nitrogen

$$\mathrm{NO} = \mathrm{N}_0 - \mathrm{NH}_e - \mathrm{N}_{\mathrm{syn}} \tag{2}$$

where: NO is the amount of influent nitrogen converted to oxidized nitrogen, [mg/L]; N_0 – influent total nitrogen, [mg/L]; NH_e – effluent ammonium nitrogen, [mg/L]; $\mathrm{N}_{\mathrm{syn}}$ – amount of influent nitrogen used in solids synthesis, [mg/L].

The amount of nitrogen used in synthesis can be estimated from the amount of BOD removed, the net solids yield (Y_n) as a function of SRT, and the nitrogen content of the mixed liquor

$$\mathrm{N}_{\mathrm{syn}} = Y_n(\mathrm{DBOD})F_n, \tag{3}$$

where F_n is the fraction of nitrogen in mixed liquor solids, [g/g].

Once NO is determined, the next step is to perform a mass balance describing the distribution of the nitrate produced in the nitrification zone, namely

$$\mathrm{N} = \frac{\mathrm{NO}}{R + r + 1}, \tag{4}$$

where N is the nitrate nitrogen concentration in the nitrification zone, [mg/L]; R – ratio of internal recycle flow (to the pre-denitrification zone) to influent flow; r – ratio of return sludge flow to influent flow.

Eq. (4) is applicable to both A/O and Modified Bardenpho system designs. The rate of nitrate nitrogen addition to either denitrification zone can be calculated once the value of N is determined.

Anoxic 1 – Volume (applies to both A/O and Modified Bardenpho)

$$V_1 = \frac{RQ\mathrm{N}}{(X)(\mathrm{SDN}R_1)}. \tag{5}$$

Anoxic 2 – Volume (Modified Bardenpho)

$$V_2 = \frac{(1 + r)NQ}{(X)(\mathrm{SDN}R_2)}, \tag{6}$$

where: V_1 is the volume of pre-denitrification zone, [m^3]; V_2 – volume of post-denitrification zone, [m^3]; Q – influent flow, [m^3/d]; X – MLSS concentration, [mg/L];

SDNR_1 – specific denitrification rate in pre-denitrification zone, [gNO$_3$ - N/gX/d],
SDNR_2 – specific denitrification rate in post-denitrification zone, [gNO$_3$ – N/gX/d].

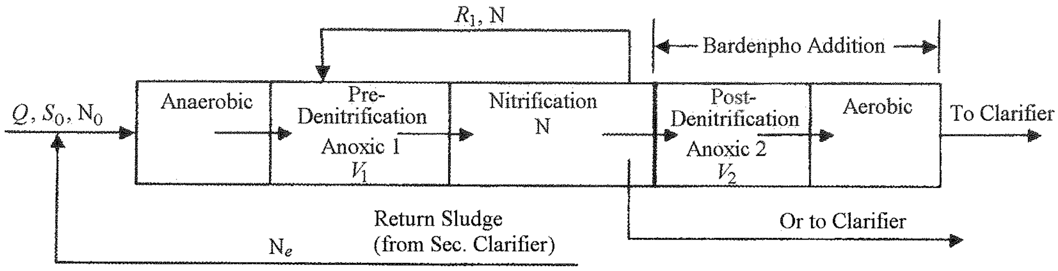

Fig. 3.– Pre-denitrification and post-denitrification schemes in biological phosphorus removal system.

The SDNR has been predicted from the specific oxygen uptake rate as follows:

$$\text{SDN}R = \frac{F_d \text{SOU}R}{2.86}, \tag{7}$$

where: F_d represents the fraction of substrate reaction rate when nitrogen – released oxygen is the electron acceptor *vs.* when DO is the electron acceptor, [g/g]; SOUR – specific oxygen uptake rate, [g O$_2$/g TSS/d].

An SDNR relationship based on the F/M loading to the pre-denitrification zone has been determined with

$$\text{SDN}R_1 = 0.03\left(\frac{F}{M}\right)_l + 0.029, \tag{8}$$

$$\left(\frac{F}{M}\right)_l = \frac{QS_0}{XV_1}, \tag{9}$$

where: $(F/M)_l$ is food-to-mass loading in pre-denitrification zone, [g TBOD/g MLSS/d]; S_0 – influent TBOD, [mg/L].

The SDNR for post-denitrification zone can be calculated as follows using an F_d factor equal to 0.5:

$$\text{SDN}R_2 = \frac{F_d A_n}{(2.86 Y_n)(\text{SRT})} = 0.175\frac{A_n}{Y_n}\cdot\frac{1}{\text{SRT}}, \tag{10}$$

where A_n is the net amount of oxygen required per unit of TBOD removed, [g O$_2$/g DBOD].

4. Conclusion

Using values for A_n and Y_n as functions of SRT, the SDNR_2 relationship shown in Fig. 4 was developed.

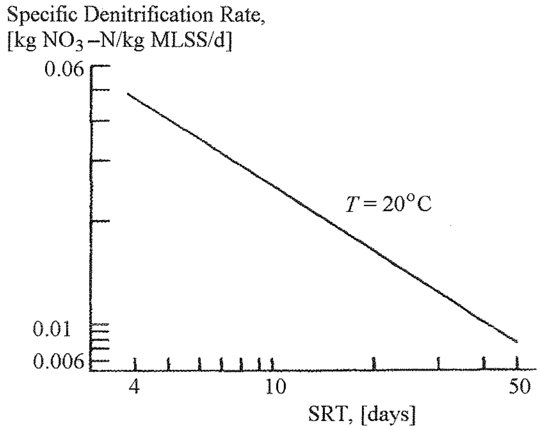

Fig. 4.– Specific denitrification rate.

A good agreement has been observed for pre-denitrification SDNR reaction rates predicted from treatment of a tannery waste-water in the presence of plentiful substrate and post-denitrification SDNR reaction rates predicted from endogenous respiration for domestic waste-water with limited available substrate.

The design procedure should check the TBOD/NO ratio to determine that there is sufficient TBOD available for amount of nitrate nitrogen to be reduced. A ratio of least 4:1 is recommended. In this case, there is sufficient TBOD available for denitrification.

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METODE DE EXTRAGERE A FOSFORULUI DIN APELE UZATE PRIN METODE BIOLOGICE

(Rezumat)

Îndepărtarea fosforului pe cale biologică din apele uzate se poate realiza prin una din următoarele variante: procedeul Phostrip; procedeul Bardenpho modificat; procedeul A/O; procedeul UCT; procedeul SBR; procedeul cu nămol activat modificat.

Alegerea uneia din metodele prezentate mai sus trebuie sa ia în considerare toate aspectele referitoare la procesul de îndepărtare a fosforului din apele uzate incluzând impactul asupra eficienţei staţiei de epurare. Astfel, există o serie de factori principali care conduc la realizarea acestui proces şi anume: a) gradul cerut de îndepărtare a fosforului; b) mărimea staţiei de epurare; c) costul total; d) impactul asupra tratării nămolului; e) impactul asupra operaţiilor tehnologice şi întreţinerii (exploatării).

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THE BIOLOGICAL TREATMENT OF WASTE-WATER
MATHEMATICAL MODELS OF STUDY

BY
ADRIAN DRĂGAN, DANIELA MATEI and M. DIMA

As a consequence of waste-water loaded with organic substances based on carbon, azote or phosphorous, the biological treatment processes became essential ones for technological scheme of treatment plant. So, throwgh an intensive examination, we have to know the theoretical and functional aspects that occur.

1. Introduction

The biological treatment processes are possible only if the waste-water under treatment has biological value, containing sufficient nutritive substances required by the biological bacteria metabolism. The organic substances like: compounds of carbon (CBO), azote or phosphorous (NTK/P_T) are part of this nutritious substances group. These mixture populations of bacteria and other microorganisms, participating on the organic substances biodegradation, are called *biomass/activated sludge.*

Knowing the bioreactor's technological diagram, we can distinguish

a) the biomass that looks like a fixed film on the surface of the filtered material, in case of a bioreactor with law or large organic load biological filter;

b) the biomass that looks like flakes (flocks) in suspension, floating into the water mass, for bioreactors having aeration tanks with activated sludge (BANA).

In this last procedure (BANA), some of the design parameters, for example

a) the organic load of sludge;

b) the activated sludge concentration into the reactor;

c) the aeration time (the time of hydraulic retention);

d) the age of sludge (the retention time of activated sludge);

e) the activated sludge recirculation

have directly influenced the quality of the influent and, implicitly, the observance the exigencies imposed by the Standards NTPA 011-2005 and NTPA 001-2005.

In what follows, the mathematical model of Lawrence and McCarty is presented that throw the adopted simplifications, gives us the required relations of calculus necessary for designing of treatment plants with nitrification–denitrification/dephosphorization imposed by European Standards.

2. The Theoretical Aspects

In terms of age sludge, the simulation that analyses all the reactions sublayer – biomass is synthetized accordingly to the technological diagram presented in Fig. 1, where: S_0, S_e represent the sublayer concentration into the influent, respective into the effluent; X_0, X_R, X_e – the biomass concentration into the influent, in the recycling one and into the effluent; V – the volume of the tank reactor; $r_{X_1} - r_S$ – the biomass concentration increase, respective the sublayer concentration decrease, resulted from the biochemical processes into the reactor; Q_0, RQ_0, Q_{ex} – the influent flow of recirculation and in excess from the reactor; $R = Q_R/Q_0$ – recirculation ratio.

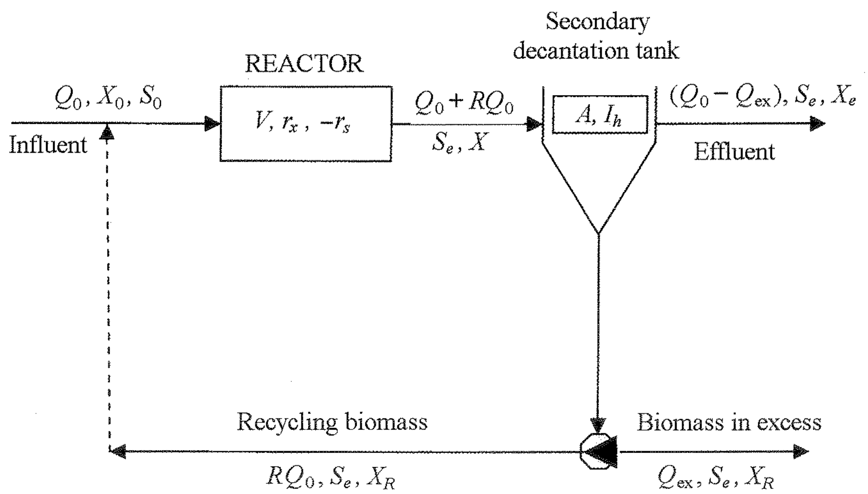

Fig. 1.– The technological diagram with a CM (compact missing) reactor and biomass recirculation (the activated sludge).

The equation of mass balance of reactor from Fig. 1, correlated with the age of sludge (TN), could be written as follows:

$$T_N = (X)_T(\Delta X/\Delta t)_T = XV[Q_{\text{ex}}X_R + (Q - Q_{\text{ex}})X_e]. \tag{1}$$

At the beginning ($\Delta t = 0$), and considering that reducing the velocity of the sublayer (the treatment velocity) is defined by, $r_S = -\mathrm{d}S/\mathrm{d}t$, and the increase velocity of biomass into the reactor is $r_x = \mathrm{d}X/\mathrm{d}t = (\mu - k_d)X = Y(-r_S)$, eq. (1) became

$$T_N = \frac{1}{\mu - k_d} = \frac{1}{r_x/X} = \left(\frac{\mu_{\max}S}{K_S + S} - k_d\right)^{-1}. \tag{2}$$

From this relation of the age sludge, are having in view the following aspects:
a) the reactor operation is quasi-stationary, meaning $(dX/dt)V = (dS/dt)V = 0$;
b) the highest aerobe level without O_2 limitation;
c) the conditions of biomass sedimentation to be eliminated into the reactor;
d) the content of active biomass in influent have to be near zero ($X_0 = 0$);
e) the elimination of sublayer occur only under specific reactions in the bioreactor, and into the secondary decantation tank those reactions are not occur.

Doing the balance of mass sublayer for the influent/effluent line, the following equality could be written:

Q_0S_0	+	RQ_0S_e	=	$(Q_0 + RQ_0)S_e$	+	$V(-r_S)$
the sublayer from the influent		the recycling sublayer from secondary decantation tank		the discharge sublayer in effluent		the sublayer eliminated by metabolic reactions

Knowing that $V/Q = T$ (the time of hydraulic retention) and the output velocity of sublayer referring to biomass is $(-r_s/X)$, the following expression results from the balance equation:

$$-\frac{r_s}{X} = \frac{S_0 - S_e}{TX}. \tag{3}$$

If the reactor's mass balance equation takes in calculation, also, the line discharge of the excess sludge (Q_{ex}), then it results

$$T_N = Y\frac{S_0 - S_e}{TX} - k_d = \frac{1}{Y}\mu_{max}\frac{S_e}{K_S + S_e} - k_d. \tag{4}$$

From these relations

$$S_e = \frac{K_S\left(\dfrac{1}{T_N} + k_d\right)}{\mu_{max} - \left(\dfrac{1}{T_N} + k_d\right)}, \tag{5}$$

$$TX = \frac{Y(S_0 - S_e)}{1 + k_dT_N}T_N \tag{6}$$

can be derived.

By introducing eq. (5) in (6) it results

$$TX = T_NY\frac{S_0\left[\mu_{max} - \left(\dfrac{1}{T_N} + k_d\right)\right] - K_S\left(\dfrac{1}{T_N} + k_d\right)}{(1 + k_dT_N)\left[\mu_{max} - \left(\dfrac{1}{T_N} + k_d\right)\right]}. \tag{7}$$

From expression (5) it results that the sublayer concentration from the effluent (S_e) is a function of the constants K_s, K_d and Y, that are specific to the adopted kinetic model and a certain value of age sludge is admitted for it (T_N). Next, it is find out that this value (S_e) does not depends on initial concentration of influent (S_0). So, for a value, T_N, maintained constant, the product TX indicates a variation of the biomass concentration from the reactor, X, function of the variation of influent's sublayer (S_0) and the quantity S_e has no further variation.

In these terms it is possible to conclude that for a set of values of the age sludge (T_N), in the reactor occur reactions that changes the concentration of substances (decrease) and of biomass concentration (increase). Thus, the sublayer concentration of the effluent (S_e) remains unchanged at the requested values in accordance with the values of emissary and the protection quality (Standards (NTPA 011-2005, NTPA 001/2005)).

Anyway, we have to take in calculus that the biomass cells multiplies with an exponential increase velocity (the second development phase), and in the last phase (of decline) takes place endogenous processes, meaning that the food is not taken from the sublayer, but is taken from the biomass. Consequently relation

$$(8)\qquad \frac{1}{T_{N_{\min}}} = \frac{\mu_{\max} S_0}{(K_S + S_0) - k_d}$$

may be written.

As concerns the minimum age of sludge ($T_{N_{\min}}$), it can vary between 2 and 20 days. The real values are obtained by their multiplication with the safety coefficients that allow a secure and efficient working of the reactors.

The link between the reactor and the secondary decantation tank could be expressed by the following balance equation of biomass:

QX_0	+	RQX_R	+	$r_x V$	=	$Q(1+R)X$
The biomass resulted from the influent and from recycling				The biomass growth		The biomass discharge from the bioreactor

In real conditions, $X_0 = 0$ and $r_x = (1/T_N)X$ and consequently the calculus equation

$$(9)\qquad \frac{1}{T_N} = \left(\frac{Q}{V}\right)\left[1 + R - R\left(\frac{X_R}{X}\right)\right]$$

is obtained.

Taking into account eq. (2), which defines and presents the calculus model of the age of sludge (T_N) and the concentration of biomass (sludge) from the reactor (X), it could be easily determine the quantity of concentration of recycling biomass (X_R).

To determine the mathematical model of the biological treatment process it is necessary to have in view the operating diagram from Fig. 1 and to add, for simplicity, the next hypothesis:

1. The treatment process takes place in a PF reactor.
2. The waste-water with the afferent sublayer is introduced into the reactor and is instantly and homogeneously mixed with the recycling biomass from the secondary decantation tank.
3. The flow capacity of waste-water from the influent is equal with the one from the effluent, which assure the maintaining of a constant volume of liquid into the reactor.
4. The biomass quantity from the influent (X_0) it is neglected with respect to the total quantity of biomass into the reactor (X).
5. The removing sublayer (S_0) occurs only in the reactor, so in the secondary decantation tank the reactions of metabolism not occur.
6. The recycling of biomass (R) from the secondary decantation tank into the reactor, is continuous.
7. The concentration of biomass into the reactor (X) represents the real quantity of biomass of the system, so it is not taking into account the activity of biomass from the secondary decantation tank.

The balance equation of biomass for the reactor–secondary decantation tank system can be put in evidence by the following equation too:

annihilation biomass in reactor	=increases biomass by recycling	+increases biomass by reactions of metabolism	–decreases biomass due to endogenous consumption	–decreases biomass by outputting the sludge

leading to

$$V\frac{\mathrm{d}X}{\mathrm{d}t} = RQ_0X_R + r_xV - k_dXV - Q_{\mathrm{ex}}X_R. \tag{10}$$

Taking in consideration the significance of the terms equation

$$\frac{VX}{T_N} = Q_{\mathrm{ex}}x_R + (Q_0 + Q_{\mathrm{ex}})X_R \tag{11}$$

could be written, if the following statements:

$$r_x = Y\frac{\mathrm{d}S}{\mathrm{d}t} = \frac{kSX}{K_S + S} \quad \text{and} \quad \frac{1}{T_N} = Yk\frac{S}{K_S + S} - k_d$$

are taken into account

Here Q_{ex} represents the flow capacity in excess of sludge (biomass), evacuating daily as the sludge in excess from the treatment system (reactor+tank).

If the recycling biomass is added (RQX_R) it results

$$V\frac{X}{T_N} + RQ_0X_R = RQ_0X_R + Q_{\mathrm{ex}}X_R + (Q_0 - Q_{\mathrm{ex}})X_R = AI_h + (Q_0 - Q_{\mathrm{ex}})X_R, \tag{12}$$

where: I_h is the hydraulic load of secondary tank or the surface load $(I_h = Q_0/A)$ and A – the horizontal surface.

The relation that permits to calculate the main parameters of the reactor (T_N, T, X) and of the secondary tank (A, I_h, X_R) too, could be written as

$$\frac{1}{T_N} = \frac{(Q_0 - Q_{ex})X_R + AI_h - RQ_0X_R}{Q_0TX}. \tag{13}$$

3. Conclusions

Considering the quantitative and qualitative aspects studied by Lawrence and McCarty, are recommended the following relations (Table 1) for technological dimensions of biological step with activated sludge from a treatment waste-water plant.

Table 1

Calculus parameter	The system of biological treatment	
	without recirculation	with recirculation
Efficiency of treatment	$\%E = \frac{S_0 - S_e}{S_0} \cdot 100$	$\%E = \frac{S_0 - S_e}{S_0} \cdot 100$, [%]
The sublayer concentration into the effluent	$S_e = \frac{K_S(1 + k_dT_N)}{T_NYkk_d - 1}$	$S_e = \frac{K_S(1 + k_dT_N)}{T_NYkk_d - 1}$
The biomass concentration into the reactor	$X = \frac{YQ_0(S_0 - S_e)}{1 + k_dT_N}$	$X = \frac{YQ_0(S_0 - S_e)}{1 + k_dT_N}$
The flow capacity of biomass evacuated from the system (sludge in excess)	$Q_{ex} = \frac{YQ_0(S_0 - S_e)}{1 + k_dT_N}$	$Q_{ex} = \frac{YQ_0(S_0 - S_e)}{1 + k_dT_N}$
The time of hydraulic retention	$T = T_N$	$T = T_N\left(1 + R - R\frac{X_R}{X}\right)$
The age of sludge (the time of cellular retention)	$\frac{1}{T_N} = \frac{YkS}{K_S + S} - k_d$	$\frac{1}{T_N} = \frac{YkS}{K_S + S} - k_d$
The minim age of sludge	$(T_N)_{\lim} = \frac{1}{Yk - k_d}$	$(T_N)_{\lim} = \frac{1}{Yk - k_d}$
The volume of aeration tank		$V = \frac{QYT_N(S_0 - S_e)}{X(1 + k_dT_N)}$

The values of kinetic constants (k, Y, K_S, k_d) will be put in evidence for each analysis model, only by studies and researches in laboratory or pilot station. Informatively, it may utilize the data shown in Table 2.

Table 2

The kinetic coefficient	Unit of measure	Limit of variation at 20°C	The mean values at 20°C
k	day^{-1}	2...10	5.0
Y	g SU/g CBO_5	0.4...0.84	0.6
	g SU/g CCO	0.24...0.40	0.4
K_S	mg CBO_5/dm^3	25...100	60
	mg CCO/dm^3	15...70	40
k_d	day^{-1}	0.04...0.10	0.06

At the biological step designing from a treatment waste-water plant, in an urban collectivity is obligatory that the indicator age of sludge, alongside other used parameters at the day, to represent both an essential designing parameter as ascertainment of unit during the exploitation.

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EPURAREA BIOLOGICĂ A APELOR UZATE
Modele matematice de studiu

(Rezumat)

Ca urmare a faptului că procesele biologice de epurare a apelor uzate încărcate cu substanţe organice pe bază de carbon, de azot, de fosfor etc. au devenit procese de bază în cadrul unor scheme tehnologice ale staţiilor de epurare, trebuie să se cunoască, teoretic şi funcţional, aceste aspecte pe baza unor cercetări intensive.

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HIDROTEHNICĂ

L'ANALYSE DU COMPORTEMENT DES TRAVAUX DE RÉGULARISATION DANS DES CONDITIONS DE CALAMITÉ

BY

MIHAIL LUCA et ION STOENESCU

On étudie la manière de comportement des travaux de régularisation, par suite des inondations des années 2004…2005, dans le bassin hydrographique de l'Olt. Les débits formés dans certains tronçons de la rivière ont dépassé les probabilités de calcul et de vérification considérés dans les project technique et ont mis en évidence la manière de comportement des travaux de régularisation des lits de la rivière. La mise en assurance de l'exploitation des travaux de régularisation anciens mais aussi nouveaux a été perturbée, menant à leur dégradation et à leur destruction. Un étude de cas, voalesé dans le bassin hydrographique de l'Olt inférieur, a imposé la considération de nouvelles directions dans les projects techniques, l'exécution et l'exploitation des travaux de régularisation.

1. Introduction

Le bassin hydrographique de l'Olt est situé dans la partie centrale et de sud de la Roumanie, étant délimité, dans la partie supérieure entre les Carpates Orientaux et le Plateau Târnave; dans la partie inférieure il est limité des l'Carpates Méridionalaux, l'Collines souscarpatiques et de la Plaine du Danube. Le bassin hydrographique de l'Olt a une surface de 24050 km^2 et une longueur de 615 km.

La diversité du relief, de la lithologie et du climat dans le bassin hydrographique de l'Olt imprime à celui-ci un régime hydrologique complexe.

L'Olt traverse dans le bassin inférieur, la région montagneuse des Souscarpates, où la vallée s'élargit sensiblamentet il apparaît des terrasses qui accompagnent le cours d'eau. Le réseau hydrographique dans ce secteur est très développé. Les affluents plus importants de l'Olt y sont: le Luncavăț, l'Olteț sur la rive droite et le Topolog sur la rive gauche.

Le Luncavăț est un affluent de droite de la rivière Olt et ses caractéristiques principales sont: la surface du bassin hydrographique F = 278 km^2, H_{moy} = 708 m, L = 57 km.

Les affluents principaux du Luncavăț sont:

a) sur la gauche, la rivière Blaj (F = 18 km^2, L = 6,0 km, H_{moy} = 1563 m);

b) sur la gauche, la rivière Ursani (F = 43 km^2, L = 12,0 km, H_{moy} = 969 m);

c) sur la droite, la rivière Mănăstirea (F = 24 km^2, L = 8,0 km, H_{moy} = 583 m).

La rivière Luncavăț et ses affluents dans la partie supérieure du bassin hydrographique sont captés par déviations pour l'accumulation Vidruța.

La géologie du secteur est mise en évidence par des dépôts miocènes représentés par: conglomérats, marnes cendrés, sables, graviers et argiles.

Les précipitations annualles dans le bassin hydrographique atteignent une moyenne de 870 mm, avec des augmentations pendant les années pluvieuses. En 1991, la quantité de précipitations a eu des valeurs de 1423 mm et en 2004 de 1021 mm.

L'activité hydrométrique dans le bassin hydrographique du Luncavăț a bien dans à quatre stations de rivière (une station pour des mesurages systématiques, deux stations pour des mesurages expéditionnaires et deux sections satellite). À chaque station hydrométrique on exécute des mesurages de niveau, des débits liquides, des températures, des précipitations et des débits solides. La dotation technique des stations hydrométriques permet l'accomplissement du programme de mesurages et d'es observations. Toutes les stations permettent la transmission des données enregistrées tous les jours.

On effectue des mesurages et des observations hydrologiques à trois forages dans le cadre de la station hydrométrique Sirineasa.

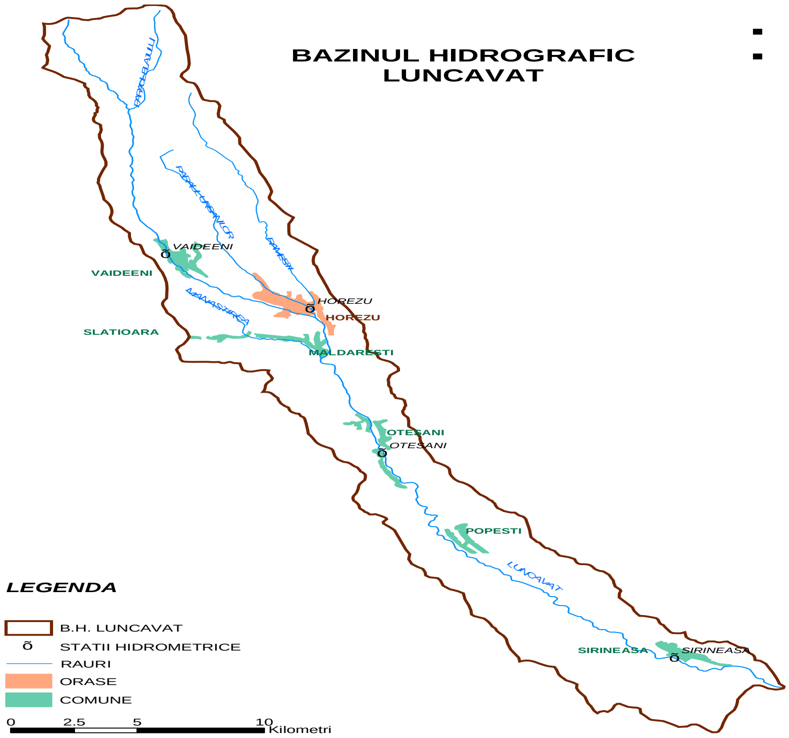

Fig. 1. Le bassin hydrographique du Luncavăț

Fig. 2. La rivière Luncavăț dans la région supérieure

2. Paramètres des crues de la rivière Luncavăț avec des influences destructives sur les travaux de régularisation

Le mois de juillet, de l'année 2004, a été caractérisé par un temps d'instabilité atmosphérique accentuée dans le bassin inférieur de l'Olt. Les précipitations ont été quantitativement élevées, à caractère torrentiel. Elles sont tombées spécialement dans la région de montagne et souscarpatique du cours supérieur des rivières: Olteț, Cerna et Luncavăț. On peut mentionerdes aires au des précipitations ont dépassé des valeurs de 50 l/m^2 dans quelques jours (Polovragi-90.6 l/m^2; Cerna -64.8 l/m^2; Vaideeni-68.8 l/m^2; Horezu-48.3 l/m). Des quantités élevées de précipitations sont aussi tombées dans les bassins Olaneşti (Olaneşti-Băi 56,5 l / m^2), Govora (Govora-village 61,5 l/m^2) et Topolog (Milcoiu 108,6 l/m^2).

Les précipitations ont été générées par des fronts atmosphériques successifs, chauds et humides, formés dans la Mer Méditerranée.

Ces fronts se sont déplacés dans la direction Sud, Sud-Qu Est / Nord, Nord-Est et se sont déchargés au contact avec la région montagneuse du sud du pays.

Le département de Vâlcea a été traversé par un autre front atmosphérique très puissant, à la fin de juillet, le 27 et le 28.Ce front, se déplaçant dans la direction Sud-Nord a généré des précipitations extrêmement intenses. Grâce aux conditions météorologiques différentes on a enregistré des crues considérables des débits sur les affluents de l'Olt du secteur inférieur. Ces crues ont dépassé les valeurs maximales admises.

De l'analyse de la manière de distribution des quantités de précipitations en temps et espace, en fonction des conditions géomorphologiques, pédologiques et le degré de couverture avec de la végétation sur la rivière Luncavăț, on a établi les crues suivantes:

a) **la I^{ère} crue** – pendant la période: 27 juillet – 1er août 2004;

b) **la II^{ème} crue –** pendant la période: 7 août – 13 août 2004;

c) **la III^{ème} crue** – pendant la période: 7 novembre – 30 novembre 2004.

À partir de l'analyse de l'écoulement maximum pendant la première crue, il résulte que celle-ci s'est produite dans le bassin moyen et inférieur par suite des précipitations intens, tombées dans ce bassin.

La I^{ère} crue, de la période 27 juillet – 1er août 2004, enregistrée aux stations hydrométriques Oteşani et Sirineasa, a été produite par les débits formés sur la rivière Urşani.

a) la valeur du débit mesuré à la station hydrométrique Horezu a été Q_{max} = 360,0 m^3/s à la date de 27 juillet, à 22 heure et 20 min.;

b) à la station hydrométrique Otesani, on a enregistré Q_{max} = 89,0 m^3/s à la date de 27 juillet, à 23,30 h/min, qui correspond à one probabilité de 12%;

c) à la station hydrométrique Sirineasa on a mesuré Q_{max} = 112,0 m^3/s à la date de 28 juillet, à 2, h, qui correspond à la probabilité de 15%.

La II^{ème} crue, de la période: 7 août – 13 août 2004, s'est produite sur la rivière Luncavat grâce tant aux précipitations très intense, tombées dans la partie supérieure moyenne de la rivière Luncavăţ, qu'au débit enregistré sur la rivière Ursani.

a) à la station hydrométrique Horezu on a mesuré Q_{max} = 50,0 m^3/s, le 9 août, à 17 h, qui correspond à une probabilité de 16%;

b) aux stations hydrométriques Oteşani et Sirineasa, les quantités de précipitations ont été plus réduites, la crue se produisant par propagation des débits de la partie moyenne du bassin;

c) à la station hydrométrique Oteşani on a enregistré Q_{max} = 71,4 m^3/s, le 9 août, à 19h et 30min, qui correspond à une probabilité de 18%;

d) à la station hydrométrique Sirineasa on a enregistré Q_{max} = 73,6 m^3/s, le 10 août, à 1h, que correspondant à une probabilité de 31%.

Les principales crues se sont produites sur la rivière Luncavăţ, dans la partie moyenne et inférieure du bassin hydrographique.

La III^{ème} crue, de la période: 7 novembre – 30 novembre 2004, a été composée et produite par la grande quantité de précipitations tombées sur tout le bassin hydrographique. La valeur moyenne des précipitations, dans le bassin hydrographique a été de 125,0 l/m^3.

a) à la station hydrométrique Otesani on a enregistré Q_{max} = 100,0 m^3/s, le 9 novembre, à 11h et 15min., qui correspond à une probabilité de 14%;

b) à la station hydrométrique Sirineasa on a enregistré Q_{max} = 112,0 m^3/s, le 9 novembre, à 13h, qui correspond à une probabilité de 18%;

c) à la station hydrométrique Horezu on a enregis tré Q_{max} = 21,3 m^3/s, le 9 novembre, à 9h et 30min.;

d) à la station hydrométrique Vaideeni on a mesuré Q_{max} = 36,3 m^3/s.

La crue de la période 13 octobre…30 novembre sur la rivière Luncavat s'est produite par suite des quantités grandes de précipitations tombées pendant dans cette période. La crue a produit des débits maxim au plus grands que ceux de la période 13.X…30.XI.2004.

À la station hydrométrique Vaideeni, on a enregistré un Q_{max} = 70,7 m^3/s, le 14 novembre, à 21 h; à la station hydrométrique Otesani, Q_{max} = 105,0 m^3/s, le 14 novembre, à 23 h, qui correspond à une probabilité de 14%; à la station hydrométrique Sirineasa, Q_{max} = 121,0 m^3/s, qui correspond à une probabilité de 18%.

3. L'analyse du comportement des travaux de régularisation à l'action des

crues

Sur la rivière Luncavăţ les grands eaux tés des présentent dans beaucoup de situations un caractère torrentiel, ce qui favorise le transport alluvionnaire et des matériaux flottants. Ceux-ci ont provoqué plusieurs fois des dégâts considérables au lit de la rivière et aux localités riveraines. Pendant les années 2004 et 2005 on a enregistré de telles situations, les travaux de régularisation étant affectés à diverses étapes.

Les rives du ruisseau Luncavăţ sont formées de dépôts facilement affouillables (argiles cendrées, sables graviers). Les paramètres mécaniques réduits du fondement intensifient le phénomène d'érosion du lit de la rivière. Il en résulte une action de transformation continuelle et importante de la forme du lit de la rivière dans le plan longitudinal et transversal.

Les rives du ruisseau ont été érodées alternativement, en provoquant la formation de méandres larges, mais aussi courtes, avec des érosions actives dans les régions concaves. Les méandres et les tournants ont été attaqués par l'érosion, pendant les crues, en résultant un lit majeur largement développé dans certains secteurs et une série de bras auxiliaires.

Pour la manière de comportement des travaux de régularisation du lit et de protection des rives, on peut mentionner:

a) Les travaux de régularisation du lit ont été affectés en diverses proportions des crues des années 2004…2006. Les constructions ont été déplacées, sous-lavées, arrachées aux fondations, disloquées de l'emplacement etc.

b) Les travaux de protection des rives, exécutés partiellement des motifs objectifs, ont été détruits ou sous-lavés. La dégradation des travaux de protection est due à la pénétration de l'eau derrière ces protections et à la destruction du contact avec la région de fondation (Fig. 3).

c) Les travaux de protection des rives insuffisamment fondés dans la roche-mère ont été détruits ou sous-lavés (Fig. 4) .

d) Les crues ont dépassé dans certaines régions la cote des travaux de protection. Dans ce cas il a résulté l'inondation du terrain agricole, des voies de communication, des régions urbaines, des régions industrielles, etc.

e) Dans la région de la ville de Horezu et des localités limitrophes, Vaideeni, Măldăresti, Oteşani, Popeşti, des inondations se sont produites au ont affecté des objectifs économiques et sociaux. Aussi, le lit du ruisseau Luncavăţ a été modifié de pourt de une morphologique.

Fig. 3. Travaux de protection des rives, insuffisamment fondés et sous-lavés par suite des crues.

Par suite des inondations de l'année 2004 on a élaboré un plan de protection des régions rurales et urbaines afférentes au ruisseau Luncavăţ. Les travaux calculés et exécutés ont eu à la base les données hydrologiques collectées des dernières crues (débits, niveaux, vitesses, transport alluvionnaire). Aussi, on a pris en considération pour le calcal, la manière de comportement à l'action de l'eau des travaux de régularisation et de protection des rives, existants le long du ruisseau Luncavat.

Les travaux calcalés et exécutés se sont différenciés par structure et matériaux employés, en fonction de l'objectif protégé et de la région d'emplacement. Les solutions calcalés ont poursuivi un encadrement correct dans l'emplacement et un comportement efficient à l'action des facteurs de l'environnement.

La manière de fondation des travaux de protection a été analysée de nouveau et on a adopté des technologies qui évitent le sous-lavage des fondations et la perte de la stabilité des constructions.

Fig. 4. - Dégradation des travaux de régularisation par suite des crues de l'année 2004.

Les solutions adoptées dans le calcul et exécutées dans le terrain ont été les suivantes:

a) des travaux de protection des rives, du type de murs de béton pour la protection des régions de l'intra-muros;

b) des travaux de protection des rives, exécutés d' sons de gabions remplis de pierre locale de rivière et fondés sur des matelas de fascines dans la région des rives soumises à l'érosion;

c) des digues de fermeture, réalisés en matériaux locaux et protégés par des gabions remplis avec de la pierre pour les régions méandreuses;

d) des barres de fond, emplacées sur des matelas élastiques dans les régions de fondation, avec des graviers et des sables;

e) des barres de fond emplacées sur des fondations en béton cyclopéen, dans les régions de fondation, avec des marnes;

f) le récalibrage du lit de la rivière par tronçons;

g) des percées de méandres avec la prise en considération de la nouvelle configuration du lit;

h) des talutages avec des matériaux élastiques pour les rives affectées par l'érosion, etc.

Une série de travaux nouveaux de régularisation trouvés en diverses étapes d'exécution ont été affectés et partiellement dégradés par suite des crues de l'année 2005. Cela a imposé l'analyse de nouveau, des données de calcul, le récolement des valeurs de calcul et l'adoption des solutions qui résistent à la nouvelle situation créée sur la rivière Luncavăț.

L'inondation fréquente des surfaces de terrain arable et des régions urbaines a imposé la modification de la cote des murs de protection. À l'exécution des travaux on a utilisé des matériaux de construction nouveaux, à performances mécaniques élevées. Dans la région des localités et des voies de communication on a adopté des solutions techniques qui résistent à l'action combinée de l'eau et des alluvions, extrêmement intensifiée les derniers ans.

4. Conclusions

1.Les crues des derniéres anneés dans le bassin hydrographique de l'Olt se sont caractérisées par le dépassement des probabilités de calcul adoptels on a établi les dimensions des travaux de régularisation sur les rivières.

2.L'action combinée de l'eau et des alluvions sur les rivières et les ruisseaux de la région de piémont a déterminé la modification morphologique du lit des cours d'eau.

3.Les travaux de protection des rives ont été partiellement ou entièrement dégradés, par suite de l'action de l'eau et des alluvions.

4.Les travaux de régularisation anciens et nouveaux projetés pour le lit de la rivière, exécutés ou, trouvés dans des phases d'exécution, ont été détruits jusqu'à l'annulation de leur rôle.

5.L'action de l'eau, à caractère de désastre, produite par suite des crues des années 2004… 2006, a imposé l'analyse des probabilités de calcul et le recalcul des dimensions des constructions de protection des rives et de régularisation de l'écoulement.

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ANALIZA COMPORTĂRII LUCRĂRILOR DE REGULARIZARE ÎN CONDIȚII DE CALAMITATE

(Rezumat)

Se prezintă modul de comportare a lucrărilor de regularizare în urma inundațiilor din anii 2004 – 2005 în bazinul hidrografic Olt. Debitele formate pe unele tronsoane ale râului au depăşit probabilitățile de calcul şi verificare considerate în proiectare si au evidențiat modul de comportare a lucrărilor de regularizare a albiilor în condițiile pentru. Siguranța în exploatare a lucrărilor de regularizare vechi, dar şi noi, a fost perturbată determinând degradarea şi distrugerea lor. Studiul de caz efectuat în bazinul hidrografic al Oltului inferior, a impus considerarea unor direcții noi în proiectarea, execuția şi exploatarea a lucrărilor de regularizare.

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INTEGRATE GPS SURVEYS AND PDA TO GATHER THE NECESSARY DATA FOR A HYDRAULIC MODEL

BY

BOGDAN VĂDUVA, RADU MARIAN, EDUARD KELLER

This paper will present how to integrate PDA and GPS surveys in order to help gathering necessary data to build the hydraulic model of a city. Our study will show how we imported the gathered GPS points into a PDA/Windows application (in house built) and how that application helped engineers in developing the model.

That application was developed for the city of Baia Mare.

Key words: GIS, PDA, hydraulic model

2008 PACS:

1. Introduction

GPS surveys

When this project started none of the people involved in it knew how it can be done and how to have the data ready for a digital use. After a few days of brainstorming and internet research we came up with a solution that fit our needs.

So we decided to have a system that will follow the next steps (figure 1):

1. Use GPS surveys to position the manholes
2. Several teams of 2-3 people with PDA's will next do the actual survey of the manholes.
3. At different points the data gathered by the teams will be merged into one database and used to do the hydraulic model.

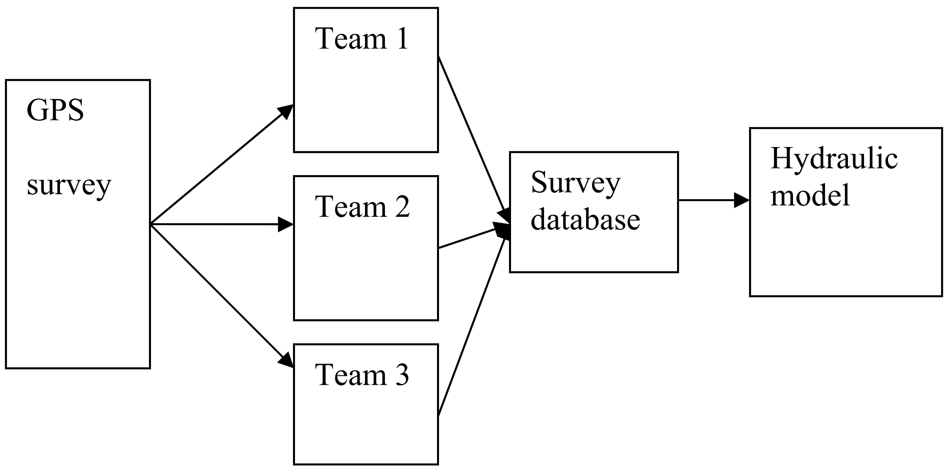

Fig.1. How data are gathered

To do the GPS surveys we used two Trimble R6 GPS Systems. The data collected with the two GPS was exported into a flat file (using Trimble Office) and later used as a starting point for our PDA application. Those points look like the ones in figure 2.

1	v.lucaciu20	685744.168	395757.778	246.509	5		CLADIRE	<By Layer	Survey quality
2	v.lucaciu19	685754.15	395687.144	246.514	5		CLADIRE	<By Layer	Survey quality
3	v.lucaciu18	685740.827	395683.436	246.531	5		CLADIRE	<By Layer	Survey quality
4	v.lucaciu16	685786.533	395496.075	243.447	5		CLADIRE	<By Layer	Survey quality
5	v.lucaciu17	685762.405	395592.661	244.659	5		CLADIRE	<By Layer	Survey quality
6	v.lucaciu15	685792.146	395472.598	243.166	5		CLADIRE	<By Layer	Survey quality
7	v.lucaciu14	685791.654	395393.058	242.261	5		CLADIRE	<By Layer	Survey quality
8	v.lucaciu13	685795.712	395357.339	241.777	5		CLADIRE	<By Layer	Survey quality
9	v.lucaciu12	685791.519	395293.638	241.094	5		CLADIRE	<By Layer	Survey quality
10	v.lucaciu11	685785.45	395235.223	240.266	5		CLADIRE	<By Layer	Survey quality
11	v.lucaciu10	685779.518	395180.896	239.861	5		CLADIRE	<By Layer	Survey quality
12	v.lucaciu9	685773.923	395129.115	239.317	5		CLADIRE	<By Layer	Survey quality
13	v.lucaciu8	685773.519	395123.034	239.304	5		CLADIRE	<By Layer	Survey quality
14	v.lucaciu7	685772.566	395111.783	239.105	5		CLADIRE	<By Layer	Survey quality
15	v.lucaciu6	685768.361	395074.632	238.64	5		CLADIRE	<By Layer	Survey quality
16	v.lucaciu5	685764.346	395033.619	238.26	5		CLADIRE	<By Layer	Survey quality
17	v.lucaciu4	685757.158	394969.146	237.613	5		CLADIRE	<By Layer	Survey quality
18	v.lucaciu3	685752.819	394940.121	237.284	5		CLADIRE	<By Layer	Survey quality
19	v.lucaciu2	685741.866	394872.525	236.554	5		CLADIRE	<By Layer	Survey quality
20	v.lucaciu1	685734.809	394823.257	236.16	5		CLADIRE	<By Layer	Survey quality
21	nisiparilor1	685559.277	394652.977	234.338	5		CLADIRE	<By Layer	Survey quality
22	nisiparilor2	685552.347	394593.026	233.336	5		CLADIRE	<By Layer	Survey quality
23	nisiparilor3	685558.289	394544.947	233.067	5		CLADIRE	<By Layer	Survey quality
24	nisiparilor4	685504.044	394377.839	231.943	5		CLADIRE	<By Layer	Survey quality
25	nisiparilor5	685478.192	394343.203	231.384	5		CLADIRE	<By Layer	Survey quality
26	nisiparilor6	685461.195	394319.323	231.015	5		CLADIRE	<By Layer	Survey quality
27	nisiparilor7	685441.477	394256.569	230.594	5		CLADIRE	<By Layer	Survey quality
28	nisiparilor8	685437.183	394239.057	230.532	5		CLADIRE	<By Layer	Survey quality
29	nisiparilor9	685430.473	394211.935	230.423	5		CLADIRE	<By Layer	Survey quality
30	nisiparilor10	685417.088	394163.537	229.948	5		CLADIRE	<By Layer	Survey quality
31	nisiparilor11	685392.603	394111.626	229.791	5		CLADIRE	<By Layer	Survey quality
32	s.barnutiu1	685372.601	393970.541	228.555	5		CLADIRE	<By Layer	Survey quality
33	nisiparilor12	685334.099	394015.785	229.073	5		CLADIRE	<By Layer	Survey quality
34	s.barnutiu2	685264.176	394083.175	229.33	5		CLADIRE	<By Layer	Survey quality
35	s.barnutiu3	685248.67	394095.415	229.475	5		CLADIRE	<By Layer	Survey quality
36	s.barnutiu4	685185.149	394137.791	231.938	5		CLADIRE	<By Layer	Survey quality
37	horea1	685168.365	394061.411	231.932	5		CLADIRE	<By Layer	Survey quality
38	horea2	685154.547	393986.902	231.143	5		CLADIRE	<By Layer	Survey quality
39	horea3	685140.91	393897.076	230.038	5		CLADIRE	<By Layer	Survey quality
40	horea4	685135.171	393871.038	229.539	5		CLADIRE	<By Layer	Survey quality

Fig. 2. GPS points

To be noted that the points are already in STEREO 70 system (conversion is made by the GPS).

At this point we have only a collection of GPS points indicating the position of manholes in the city.

I will make a note at this point saying that we got a little help from an external consultant which had provided us with a survey format. This survey format was followed when we developed the PDA application. Someone could ask at this point why we needed the PDA application.

So for those who have this question in their minds we will answer saying that digital data is the only useful data in GIS.

For the application we decided to use SQL Server mobile edition because:

- is mobile (can be use on PDA devices) and also can be used on Windows systems with the appropriate software installed
- the data can be manipulated with SQL commands
- the data can be easily converted into a SQL Server 2005, MySQL or PostgreSQL

In order to be able to manipulate manholes we decided to have codes for every street. For every street the manholes will be numbered starting from 1. So if the street code is for example 10 and we have 4 manholes on that street, the complete set of codes will be 10_1, 10_2, 10_3, 10_4. In this way we can't mix up the manholes codes and are easy to read.

2. The Application

At this point we will start presenting the PDA application (figure 3).

Fig. 3. Main screen of the PDA application

This application has a few options. We will present each option:

- Fisiere (File) with the following suboptions (figure 4):
  - Export … - used to export the entire database content into Excel files
  - Iesire (Exit) – exit the application

Fig. 4. File menu

- Coduri (Codes) with the following suboptions (figure 5):

Fig. 5. Codes menu

  - Creare (Create) – to create new street codes (figure 6)

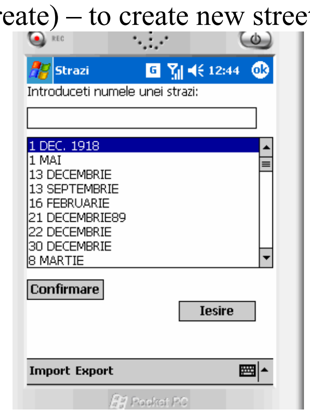

Fig. 6. Create option

At this point we will notice the two options available (figure 7 and 8): Import and Export. Import is used to import the GPS points into the application and Export is used to export the data into an Excel file format, which can be easily imported into the database of choice. Be careful in choosing the database because the effort involved in moving the data is the same either you are using some home use database or a more serious one. By using inappropriate database servers you can find yourself in that situation in which you will have to do the above step again, but using a different database server. **It is a waste of your time!**

Fig. 7 Import option

Fig. 8 Export option

- o Vizualizare coduri strada (View codes - street) – to view street codes
- o Vizualizare coduri introduce (View codes - insert) – to view the entered street codes (figure 9)

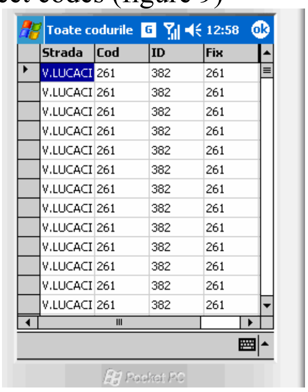

Fig. 9. View codes

- Detalii… (Details) – used to enter the actual survey of the manhole. The user will work on a street at one moment. So he/she will have to select the street using a search screen (figure 10).

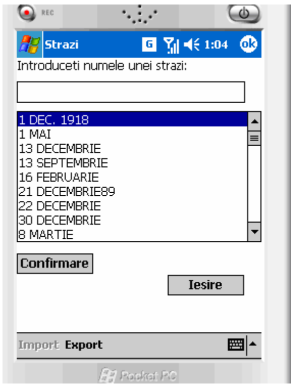

Fig. 10. Details option

To note that we tried to use similar user interfaces.

Once a street was selected a selection screen for the manhole numbers will appear (figure 11).

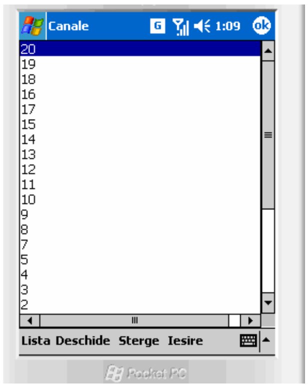

Fig. 11. Manholes numbers

The user has now the ability to select a manhole and work with it. Once he selected a manhole a new screen will popup (figure 12, 13, 14, 15, 16, 17)

.

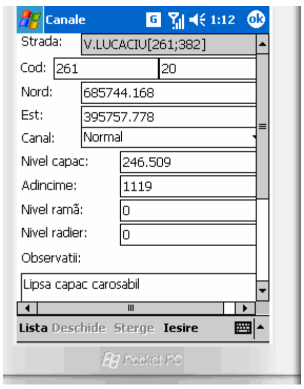

Fig. 12. General information (1)

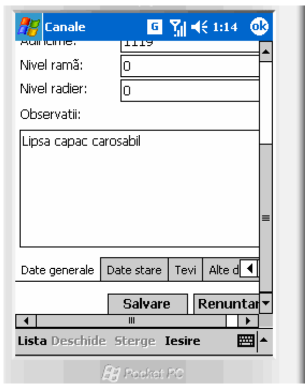

Fig. 13. General information (2)

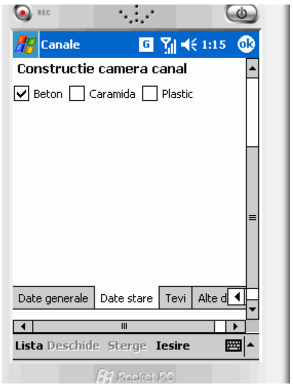

Fig. 14. Manhole status

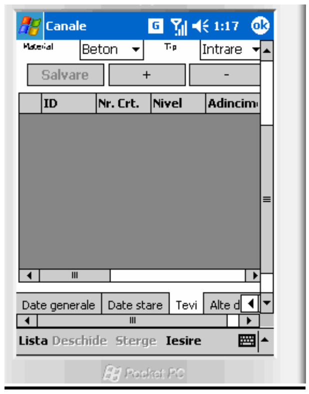

Fig. 15. Pipes

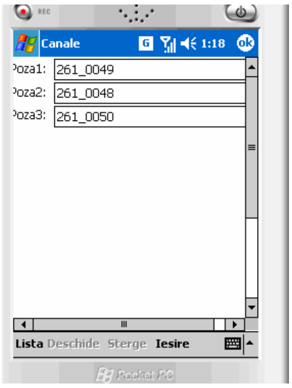

Fig. 16. Pictures

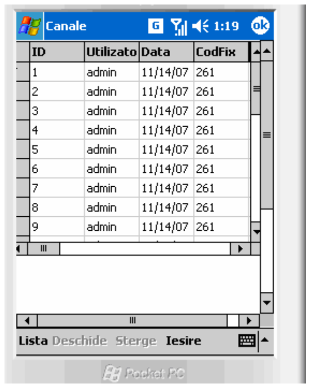

Fig. 17. List view

Of course the project wasn't an easy one and we've got issues. The main issue that we confronted with was the level of computer knowledge for the people doing the survey. Some of them weren't able to use the PDA's and they did the surveys on paper, those surveys being entered into the database at a later time. To do that the same application can be started on Windows systems.

Once the data is populated it can be merged into a single database which can be used in a different software as a starting point. In our case InfoWorks was the software of choice and that was used to produce the hydraulic model. At the time this article has been written about 3000 manholes had been surveyed.

3. Conclusion

We will conclude our short article with a few notes/recommendations:

1. Be open in using in house built software (GIS is not only of the shelf products)

2. Be flexible when developing the software by providing exports to different formats
3. PDA applications **can** be integrated with GPS

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R E F E R E N C E S

1. Internet - http://www.trimble.com, http://www.microsoft.com

UTILIZAREA GPS-urilor si a PDA-urilor IN CULEGEREA DATELOR NECESARE CONSTRUIRII MODELULUI HIDRAULIC AL UNUI ORAS

(Rezumat)

În această lucrare am prezentat cum am integrat GPS-urile şi PDA-urile pentru a culege datele necesare construirii modelului hidraulic al unui oraş. Modalitatea noastră de integrarea a fost următoarea:

1. Una sau mai multe echipe au identificat canalele folosind GPS-urile
2. În pasul următor s-au trimis mai multe echipe pe teren pentru a completa formularele (culegerea de informații)
3. Datele culese de echipe au fost îmbinate la sediul firmei
4. Datele adunate au fost exportate într-un format care permite importul în aplicația de generarea a modelului hidraulic

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SOME ISSUES CONCERNING THE SLUDGE GENERATED BY URBAN WASTE WATER PURIFYING STATIONS AND THE CAPITALIZATION ON MUNICIPAL MEADOW SOILS

BY

MIHAI DIMA and ILINCA DINU

In this paper, the authors analyzed on the basis of thorough observations on the quality of the mineralized organic sludge from urban purifying stations the risks and benefits of applying it on land in order to increase agricultural production .In particular, to analyze the situation amendment of agricultural land on the meadow.

1. Introduction

Waste water purifying stations process: purified water that must be reintegrated in the environment without jeopardizing the quality of and depositing materials from water in most cases of organic nature.

Fresh sludge (unprocessed) presents a real danger (impact) for the environment because of it’s fast fermentation. For this reason, it is compulsory application of techniques of mineralization. Large quantities of sludge must be reintegrated in environment. A form of reintegration is the evacuation in marine waters, but especially their recovery in agriculture.

Applying sludge on agricultural lands has the advantage of being the least expensive method of neutralizing and recycling of the organic waste according with the general concept of organic recycling, neutralizing and improvement of the existing ecosystems.

Many developed countries of the world such as USA, Japan, China, the European Union countries such as France, scatter sewage sludge on the agricultural land. This process provides certain economic benefits to agriculture through the fertilization properties of sludge considered to be a source of mineral elements for the crops.

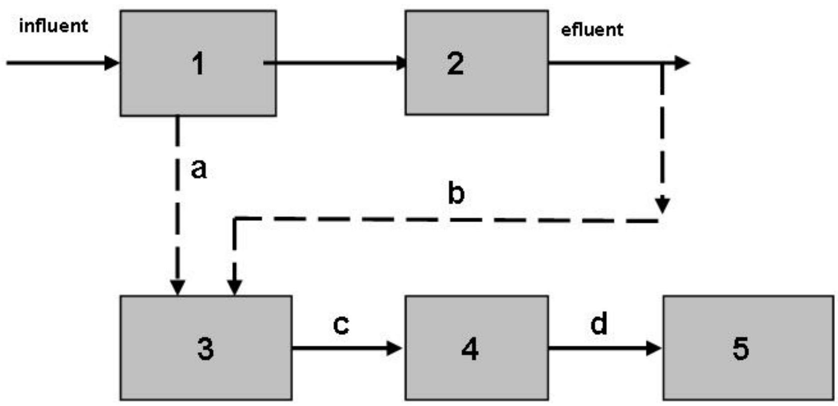
2. Evaluation of the possibility of using sludge in agriculture

2.1. Types of sludge and their main features in the cleaning station

The sludge from the purification of wastewater can be categorized after: chemical composition criterion (mineral sledge, which contains 50% mineral substances and organic sludge, which contains over 50% volatile substances); the step of purging criterion (primary sludge , a result of the mechanical cleaning step ;secondary sludge resulted from the biological step of purification and anaerobe stabilized mud(resulted from the fermentation tanks of the sludge) or aerobic (result either from the advanced biological treatment or from mud stabilizer); wastewater origin criterion (sludge from purifying domestic / municipal waste water and sludge from industrial waste water cleaning).

To efficiently treat and evacuate the sludge retained in the cleaning stations as is very important to know their characteristics.

Municipal waste water sludge characteristics can be grouped into: physical, chemical, biological and bacteriological.



(1)– mechanical step; (2)- biological step; (3)- sludge mineralization tank ; (4)- = sludge dewatering ; (5) – final sludge deposit (a) – primarily sludge; (b) –biological sludge; (c)- digested sludge mineralized sludge (d) – dry sludge for agriculture. In particular, we are interested in chemical characteristics related to the substances content in fertilizers (N, P, K), in heavy metals and the biological characteristics with reference to the content of pathogenic agents of sewage sludge.

Fig.1 Flow sheet of a purification station:

2.2. Mineralization processes of sludge from urban purification stations

Technically the mineralization of organic sludge is performed applying the following methods:

1. Biological anaerobic sludge digestion which takes place in special equipment, called fermentation containers (methane containers) that run in temperatures of 30 – 35° C (mezophilic), 33 – 45° C (termophilic) or at ambient temperature (criophilic) . Anaerobic fermentation is the most often used method in the wastewater treatment stations. Anaerobic fermentation produces a product called secondary fermentation gas (biogas), recommended to be applied in all EU legislation as a renewable energy source.

2. Aerobic sludge digestion is recommended especially for small amounts of the organic sludge. Aerobic fermentation is done in practice on open basins, as stabilizing the mud (on line treatment of sledge), or on the aeration basins of the water line that provides an advanced purge of the sludge. For residual solid waste (agricultural scrap and in animal husbandry units) are applied mineralization solutions in stacks, where the temperatures of up to 40 ° C, resulting a compost, used mainly as fertilizer in organic agriculture.

Comparing the two systems of stabilizing organic sludge, the conclusion is that the anaerobic process of stabilization in more advantageous particularly in terms of energy.

In Table 1 are given comparative data for the two processes.

Table 1.
Comparative data on anaerobic and aerobic fermentation

Method	Retention period days	Energy consumption KWh/m3 mud	Features
Aerobic fermentation	8 - 15	5 - 10	Simple procedure, low cost investment, high energy consumption
Anaerobic fermentation	15 - 20	0,2 - 0,6	Operating high cost, investment high cost; low energy consumption; gas production (source of energy).

2.3. Key points for successful sustainable use of sewage sludge

Using the method of agricultural recovery of sewage sludge is an advantage not only for farmers but also a whole range of third parties, including producers of sewage sludge (managers of water treatment stations), carriers or a unit specializes in technical achievement of the dispersal and incorporation of sewage sludge etc.

a) For the success in the sustainable use of sewage sludge is required: For the acceptance of the use of sewage sludge by farmers and consumers wittingly it is necessary good information on the technical conditions of mineralization and on the chemical composition in fertilizers substances of sludge, of conditions and the application system on soil.

b) Organization on the regional level through a smooth distribution of experimental fields in which the sewage sludge is used (the spreading is based on soil type, crops, land use etc. and take into account already existing contribution in the domestic animal dejections in rural areas); A well organized analytical scrutiny to ensure the origin of spread sludge and the soil that receives it (knowing the quality of sludge and the soils ability to receive it);
c) A very good thinking of applying mineralized sludge from purification stations in order to capitalize on the best properties of these fertilizers;
d) A code of best practices for implementing of sewage sludge for every interveners to do exactly what should be done;
e) The estimation of results obtained on national level in order to capitalize agricultural areas with organic sludge.

2.4. The risk of using sewage sludge in agriculture

The recycling of sewage sludge, after the elimination of chemical substances that have a significant impact on the quality of soil and groundwater on agricultural land is generally regarded as the best practical option for the environment.

In addition to nutrients, the sludge have varying quantities of heavy metals whose accumulation in soil over certain limits, can negatively affect life in soil, plant life, the quality of agricultural products, the environment as a whole.The concentration of heavy metals in sewage sludge is limited because of the possibility of transfer from land through plants, along the food chains until the final consumer – the man.

Worldwide there are concerns for determining content limits for heavy metals in sludge, but they are not yet firmly established by legislation. And in our country there are some recommendations of ICPA/2005 upon the admission of heavy metals in sludge: CD - 10 ppm, Cr - 500 ppm, Ni - 100 ppm, Pb - 300 ppm, Zn - 2000 ppm, Cu -- 500 ppm, Co - 50 ppm, etc. Heavy metal content in sewage sludge is mainly due to the industrial wastewater discharged into the municipal sewerage. To decrease the toxic elements it is necessary a correct pre-treatment of these effluents in the industrial enterprises, along with inorganic sludge results retention.

Another problem related to the use of sewage sludge in agriculture is possible due to their pathogen potential. This sludge can contain bacteria, viruses, protozoa parasites, worms. There are fears that some of these micro organisms could reactivate even after a certain time after the sludge composting process.

The hygiene procedures aimed for sterilization of the sludge (pasteurization, irradiation), and for stabilization (using high temperatures and pressures treatment), cleaning being obtained as a side effect.

3. Studies on using sewage sludge as fertilizer in organic agriculture

Technical literature indicates that the use of sludge from the water cleaning stations in agriculture is done either in liquid state of sludge a resulted from methane containers and applied by spraying on fields or in solid state (dry sludge) applied by spreading on agricultural areas.

Also technical literature shows that all the experiences have developed the following features: applied mud doses were 10, 30, 50, 70 t / ha, the application of sludge was achieved: under the ploughing at the lawns foundation (autumn); under the plough (autumn), and the establishment of the lawn and every year at the surface of the ground; they resorted to annual chemical fertilization: c1 = N0 P0; c2 = N100 P2O5 50; tests were done on untreated soil with mud but fertilized with chemical fertilizers; mixture of perennial: graminaceae and leguminous plants: couch grass (Dactylis glomerata) and shamrock (Trifolium repens).

Reaping was done by mowing scythe I at the coming into ear of coach grass and the following scythes at intervals of 40-45 days.

3.1. The influence of fertilization with sewage sludge upon the production and quality of the fooder on temporary lawns used for mowing -Experimental results obtained in the first year of research

The unfertilized lawns achieved a production of 8.3 tons/ha of dry substance (SU) (Table 2). The sludge applied at the establishment of the lawn under the plough, causes the increasing of production with 24% at maximum dose of 50 t / ha, with 11% at dose of 30 t / ha and only 5% of the dose of 70 t / ha mud. On chemical background (N100 P2O5 50), the production increases achieved by applying sludge are smaller, between 4 and 19%, the most viable version remaining the one with 50 tons / ha (19%).

Table 2

Production of dry substance in the first year of research

The implementation of sludge	Dose of sludge (t/ha)	Without chemical fertilizers		N-100 P_2O_5-50		Average	
		t/ha S.U.	%	t/ha S.U.	%	t/ha S.U.	%
Under the ploughing at the lawn foundation	0	8.3	100	10.5	100	9.4	100
	10	7.7	92	10.6	101	9.1	97
	30	9.2	111	10.9	104	10.0	106
	50	10.3	124	12.5	119	11.4	121
	70	8.7	105	12.1	115	10.4	111
Average		8.8	-	11.3	-	10.0	-
Every year under the ploughing	0	8.3	100	10.5	100	9.4	100
	10	10.5	126	12.1	115	11.3	120
	30	12.0	144	13.3	127	12.6	134

The implementation of sludge	Dose of sludge (t/ha)	Without chemical fertilizers		N-100 P_2O_5-50		Average	
		t/ha S.U.	%	t/ha S.U.	%	t/ha S.U.	%
	50	13.5	163	13.7	130	13.6	145
	70	13.6	164	12.9	123	13.2	140
Average		11.6	-	12.5	-	12.0	-
Average		10.2	-	11.9	-	-	-

By applying sludge under the plough on the lawn area each year in the autumn time without chemical fertilizers, increases production to the standard one with 26% to 64% (the highest growth was recorded in variant fertilized with 70 tons / ha mud).

On the merits of chemical fertilization increases are only 15-30%, although a tendency for uniform production starting dose of 30 t / ha sludge. The average dose of 10 t / ha mud does not lead to an increase of production with insurance statistics to the unfertilized meadow, regardless of how the administration and combining it with chemical fertilization.

By applying sludge at the establishment of the lawn every year using chemical fertilization too, the production increase to the standard one (10t/ha) is smaller (6-15 %), having a significantly statistical assurance just in case of 50 t /ha dose ((increase of 1.75 tons / ha SU).

<u>Experimental results obtained in the next year</u>

Being in the final year of operation (the 4th), yields are much lower compared to the previous year. It also notes, a quite obvious uniform production, depending on the treatment applied. The unfertilized meadow achieves a production of 5.7 tons / ha SU. The mud applied to the establishment of the lawns under the plough, causes small production (2% dose of 10 t / ha and 9% at dose of 50 tons / ha). On chemical background (N100 P2O5 50), the production growth achieved by applying sludge are higher (12-31%), highlighting the version with 50 tons / ha (31% growth).

Table 3

Production of dry substance in the next year

The implementation of sludge	Dose of sludge (t/ha)	Without chemical fertilizers		N-100 P_2O_5-50		Average	
		t/ha S.U.	%	t/ha S.U.	%	t/ha S.U.	%
Under the ploughing at the lawn foundation	0	5.7	100	5.7	100	5.7	100
	10	5.8	102	6.6	116	6.2	109
	30	5.3	93	6.4	112	5.8	103
	50	6.2	109	7.5	131	6.8	120
	70	5.3	93	6.4	112	15.8	103
Average		5.7	99	6.5	114	6.1	107

The implementation of sludge	Dose of sludge (t/ha)	Without chemical fertilizers		N-100 P_2O_5-50		Average	
		t/ha S.U.	%	t/ha S.U.	%	t/ha S.U.	%
Every year under the ploughing	0	5.5	100	5.3	100	6.1	107
	10	4.9	80	6.5	123	5.7	105
	30	7.5	126	8.6	162	8.0	149
	50	6.5	118	7.3	138	6.9	128
	70	7.2	131	7.3	138	7.2	134
Average		6.3	115	7.0	132	6.6	123
Average		6.0	107	6.8	123	6.4	115

Doses of sludge applied, did not cause production spores with insurance statistics to the unfertilized lawns, regardless of how the administration and combining it with chemical fertilization.

By applying sludge annual ploughing under the establishment of the lawn the production increases by only 0.77 t / ha SU, compared with the fertilizer application only to the establishment lawns as ploughing, growth without statistic insurance.

And in the years of drought chemical fertilizers have positively influenced the production of dry substance and the production growth record (0.98 t / ha) compared to the unfertilized variations that have a distinct significant statistical insurance.

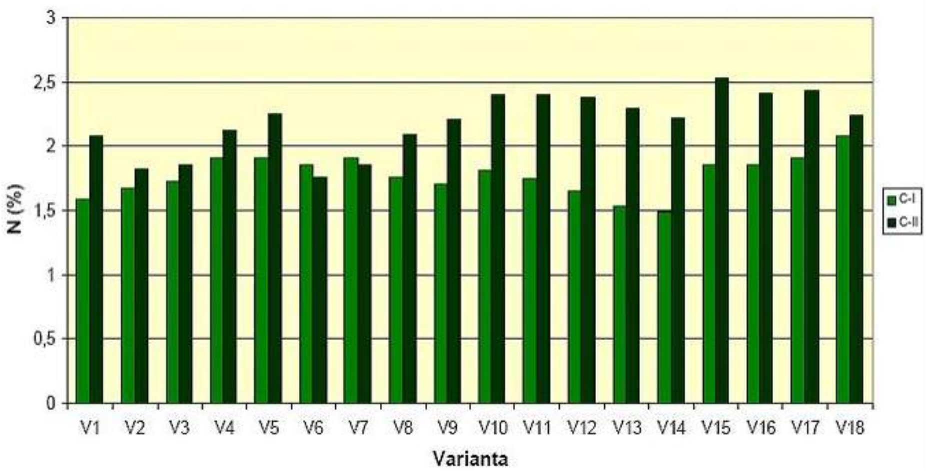


Fig.1 The content in nitrogen of hay in scythe I compared with scythe II

The data presented shows that annual applying of sludge at the establishment of the lawn does not produces changes to the chemical composition (macro elements and base metals) of hay where doses sludge up to 70 tons / ha.

As regards the largest share between experiment factors, the best results were when using chemical fertilizers (10.72%), with significant statistical insurance. The other two factors (the dose of sludge and the implementation) had an approximately equal contribution (about 6%) without insurance statistics, and interaction of factors is evident only when a dose of mud x way of implementing (12.79%) without statistic insurance.

The content in nitrogen of hay was much higher in scythe II compared with a scythe I, as can be seen from the figure 1.

3.4 Conclusions

Following the procession of data from the annual reports on the use of sludge from purification stations shows that the use of sludge in agriculture is increasing. The use in agriculture of an 18% of sludge generated in 2003 led to the use of 29% of sludge generated in 2005. This is due to modernization of purification stations that provide the cleaning and upgrading the line treatment sludge.

Following studies shows that the use of sludge in agriculture is a very used and appreciated because of all advantages and because of very good sanitation of sewage sludge and co-composting of solid waste.

Agricultural use of sewage sludge is one method of clearing it and a form to value their contents in organic matter and nutrients. The research on the use of sludge from purification stations in agriculture make different assessments of the behaviour of soils and plant production. Sludge result from municipal waste water purifying process increase production of dry substance on the temporary lawn only when taken as ploughing the establishment of the lawn and repeated every autumn, without addition of chemical fertilizers.

Small doses of sludge (10 tons / ha) does not significantly influence the production of dry substance, regardless the mode of administration and chemical variant of fertilization. Regardless of dose, the use of sludge and a moderate fertilization with chemical substances do not show significant effect on production meadow.

In terms of production of dry substance, it is advisable a sludge application in doses of 30 to 70 T / ha, at the establishment lawn and repeated annually, without chemical fertilizers. Chemical analysis (macro elements and content of heavy metals) of hay shows that there are no statistical assurance changes in the chemical composition (compared with the witness unfertilized land), where the doses of fertilized mud were up to 70 t / ha.

Quantities or doses of sewage sludge applied on the land can not be recommended whereas they should be calculated on the basis of the content of heavy metals in sewage sludge and soil. Another factor taken into account is the appropriate doses of nutrients for cultivated species, but this factor is quite relative because of excessive doses of sludge may lead to the increase of content in heavy metals in soil and plants.

All these aspects should be researched and published by our team of specialists.

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UNELE ASPECTE PRIVIND VALORIFICAREA NAMOLURILOR DIN STATIILE DE EPURARE URBANE ASUPRA SOLURILOR PAJISTILOR COMUNALE

(Rezumat)

In aceasta lucrare, autorii analizeaza, pe baza unor aprofundate observatii asupra calitatii namolurilor organice mineralizate din statiile de epurare urbane, riscurile si avantajele aplicarii acestora in vederea cresterii productiei agricole. In particular, se analizeaza situatia amendarii terenurilor pe pajistile agricole