"PROTEUS" A NEW DEVICE FOR APPLICATION OF COAGULANTS DIRECTLY TO SEDIMENT DURING ITS CONTROLLED RESUSPENSION.

RYSZARD WIŚNIEWSKI[1], JERZY ŚLUSARCZYK[2], TOMASZ KALISZEWSKI[2], ADRIAN SZULCZEWSKI[2], PRZEMYSŁAW NOWACKI[2]

[1]Nicolaus Copernicus University, Institute of Ecology and Environment Protection, Toruń, Poland, wisniew@biol.uni.torun.pl

[2]Prote Technologies for Environment Sp. Z o.o., Poznań, Poland, www.prote.pl

SUMMARY

The main problem in overeutrophicated lakes there is accumulated in sediments phosphorus. Trials of solving this problem come down to costly removing deposits or not much effective administering the coagulant to the surface water layer.The designed "Proteus" device guarantees the full control of coagulant concentration, and the depth of applicating it directly to deposits, letting get the great effectiveness of PO_4 inactivation. The device consists of the surface module containing navigation system , and control system of the administered substance concentration, and of the underwater module with the chamber and nozzles to administering coagulant in the time of extorted resuspension .

Generally the principles of operation resemble solutions of Rippl (1976) and Quaak et al. (1993). The difference consists in earlier triggering intense resuspension of deposits and on administering coagulant to the accurately determined layer of deposits

Both resuspension as well as coagulation process is running inside the underwater module what restrict the possibility of getting out of sediment particles. It allows for controlling parameters of coagulation, optimizing the process, and thus can be an effective method of phosphorus inactivation.

THE RATIONALE FOR APPLYING COAGULANT DIRECTLY INTO SEDIMENT

Fig. 1- 2. Possible effects of injecting alum into water. - (Myers, at all. 2004. Report)

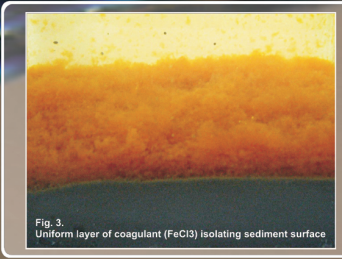

Fig. 3.
Uniform layer of coagulant (FeCl3) isolating sediment surface

Fig. 4. Resettling coagulant after gas bubbles release

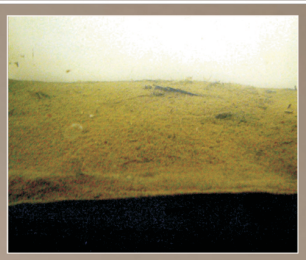

Fig. 5. Sediment surface after applying FeCl3 during forced sediment resuspension

"...resuspension of sediment (polymictic lake) removed the alum hydroxide layer on the sediment surface, which reduced treatment effeciveness." - Hullebusch, at all. 2002. - (Environmental Pollution)

COMPARISON OF PHOSPHORUS CONCENTRATION REDUCTION AFTER APPLYING COAGULANTS INTO WATER, AND INTO RESUSPENDED SEDIMENT

Lake	Surface ha	Volume thous. m^3	Depth max. m	Depth mean m	Length max. m	Width max. m	Shore line develop.
Winiary	14.4	302.4	4.2	2.1	1050	230	1.90

Table 1. Basic parameters of lake Winiary.

Fig. 6. Lake Winiary in Gniezno.

Fig. 7. Experimental setting. Left series - coagulant applied into water. Right series - coagulant applied directly into resuspended sediment.

PROTOCOL:

Ten of 2 l volume aquariums were filled with 350 cm^3 of sediment and lake water - containing 0.441 mg P-PO_4/l - (preventing sediment resuspension).

One series of 5 aquariums were designed for applying coagulant into water, the other 5 for applying coagulant during forced sediment resuspension.

First aquarium in series served as control, i.e. no phosphorus, and no coagulant was added. To the rest of aquariums 2.0 mg/l of PO_4 (as KH_2PO_4) was added.

Every aquarium, except first pair, contained thus in water 1.095 mg/l of P-PO_4. Measured Ptot in sediments was 3.268 mg/ g. d.m., from which 74% were mobile fractions.

Coagulants were applied as follows
aquariums 2 A and 2 B - 5.0 ml/l of $Al_2(SO_4)_3$ (working solution 50g/l)
aquariums 3 A and 3 B - 5.0 ml/l of $FeCl_3$ (working solution 50g/l)
aquariums 4 A and 4 B - 1.05 g/l of Phoslock
aquariums 5 A and 5 B - $FeCl_3$ + $Ca(NO_3)_2$ - 3.0 ml/l + 2.0 ml/l (working solutions 50g/l)

Six hours after coagulant application phosphorus and suspension concentrationwas measured, then sediment resuspension was involved in all aquariums.

After next 6 hours measurement of phosphorus and suspension concentration was repeated.

	Control		$Al_2(SO_4)_3$		$FeCl_3$		Phoslock		$FeCl_3$ + $Ca(NO_3)_2$	
	A	B	A	B	A	B	A	B	A	B
P-PO_4 mg/l	P-PO_4	P-PO_4	P-PO_4	P-PO_4	P-PO_4	P-PO_4	P-PO_4	P-PO_4	P-PO_4	P-PO_4
6 hours after flocculant addition	0.441	0.193	0.016	0.156	0	0.082	0.033	0.193	0.016	0.049
	Resuspension in both series									
6 hours after resuspension in both series	0.984	0.441	0.651	0.255	0.539	0.23	0.502	0.218	0.329	0.156
Suspension	d.m. mg/l	d.m. mg/l	d.m. mg/l	d.m. mg/l	d.m. mg/l	d.m. mg/l	d.m. mg/l	d.m. mg/l	d.m. mg/l	d.m. mg/l
after 6 h		38.1		12		7.1		60.1		18
after 12h	109.9	60.7	67.6	44.3	82.7	18.1	70.7	57.6	63.4	35.4

Table 2. The results of phosphorus inactivation applying different coagulants into water, and into resuspended sediment.

DEVICES FOR APPLICATION OF COAGULANTS DIRECTLY TO SEDIMENT.

Existing solutions:

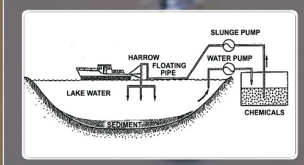

Fig. 8. Riplox. Eiseltova 1994.

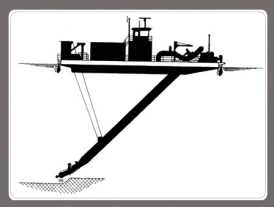

Fig. 9. Quaak, 1993

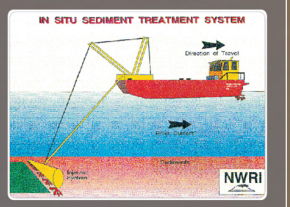

Fig. 10. Limnofix in-situ sediment treatment (LIST) process (www.oceta.on.ca)

The "Proteus"

Prototype tests. Lake Winiary 2006.

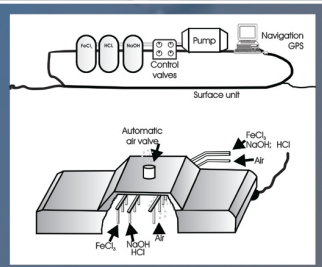

Fig. 11. The "Proteus" scheme.

Fig. 12. Surface unit.

Fig. 13. Underwater unit.

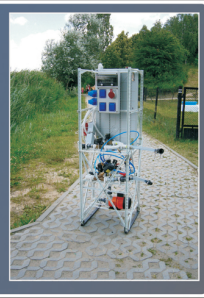

Fig. 14.
Coagulant dosing control system.

Fig. 15. Injecting element.

Fig. 16. Improved shield of underwater unit.

CONCLUSIONS

Applying the coagulant to the water volume isn't guaranteeing getting solid and long-lasting layer of coagulant, preventing PO_4 release from deposits effectively. It is essential in the case of shallow lakes.

In the case of accidental sediment resuspension after carrying the treatment out, the amount of phosphorus released from bottom deposits depends from the way of applying the coagulant. It is about twice smaller at administering the coagulant directly to deposits.

The designed "Proteus" device enables the precise control of the coagulant concentration, pH, redox potential and depth of applying it to deposits, letting get the optimal effectiveness of PO_4 inactivation.