MEMBRANE DOSING UNITS FOR CHEMICALS IN WATER AND WASTEWATER TREATMENT

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ABSTRACT

It is well known that in the practice of the drinking water as well as of the wastewater treatment especialy for the processes of pH-regulation, flocculation, precipitation or decontamination dosing of reagents is necessary.
The costs of the automatic dosing stations are comparatively high. For the smaller water treatment plants these stations are uneconomical and charged with maintenance problems very often.
In many cases the frequently observed highly fluctuating reagents needs and their recess can cause disruption of the normal exploitation work. These disadvantages can easily be overcomed by a device based on permeable or semi-permeable membranes.
The use of semi-permeable membranes is favorable especially in the cases of fluctuating water quantities or standstills. It can be effective because of the possibility for their self-regulation during the dosing. When there is no inflow available some kind of a concentration equilibrium is established between the membrane internal and external layers. This system is easy to install and it can easily adapt to the local conditions.
The device can be a canister filled with the desired reagent and having a lid of a definite semi-permeable
membrane.
After determining the permeability of the membranes made of different materials only the appropriate membrane resp. membrane area was investigated.
Developed methods for defining the specific membrane permeability are disscussed in the paper. Suggestions for the application of such devices in the practice are given as well.

KEYWORDS

Membranes; dosing chemicals; water and wastewater treatment, canister

INTRODUCTION

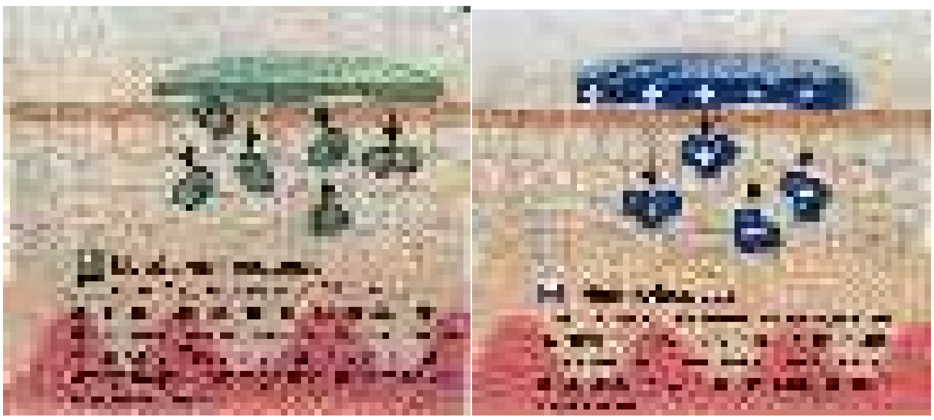
The aim of the present research is to investigate the possibility for developing economical and easy for exploitation dosing devices used to provide chemicals based on diffusion or dispersion of substances through semi-permeable or permeable membranes as well as to determine the main parameters defining the mass transport through them.

BASICS

In the study an attempt to define a general decision method for optimum dosage of the known chemical is made.
The following problems of the conventional dosage are well known:

- Loss of chemical when the transport pipe lines are blocked;
- Providing in the drinking water high carcinogenic polycyclic aromatic hydrocarbons (Bollin G.E., J.F. Plouffe et al., 1985) which are inevitably present in tars, rubber gaskets, tallow ropes, machine oil, grease and create conditions for development of pathogenic microflora of the kind Legionella Pneumophiliya (Legionary disease);
- Incorrect dosage /over-dosage/(Overath H., H. Lang, 1982), which leads to:
    - Violations of the water quality standards with respect to the efluent;
    - High turbidity, blocking the filters' work, undesired secondary coagulation, low effect of disinfections;
    - Increased exploitation expenses;
- Problems which can emerge in the dosage of chemical reagents for neutralization or keeping the level of pH for biological processes;
- Dispersing of the chemicals in the water. According to many authors (Allied Colloids Co. Ltd, Gelgard GmbH, 1998 and Degremont, 1994) this is what determines the success or the failure of the chemicals treatment.

These problems of the conventional dosage could be easily solved by the means of a doser based on the defined membrane permeability.
In the presented paper membrane dosers are investigated as a possible alternative of the traditional dosers.
It is well known that the membranes are used for dosing of medicines (Spiegel Wissenschaft, 1997). In (Fig. 1) is shown how different membranes are used for medical purposes. To enhance the diffusion different forces like electrical, ultrasonic, magnetic fields a.o. are used.



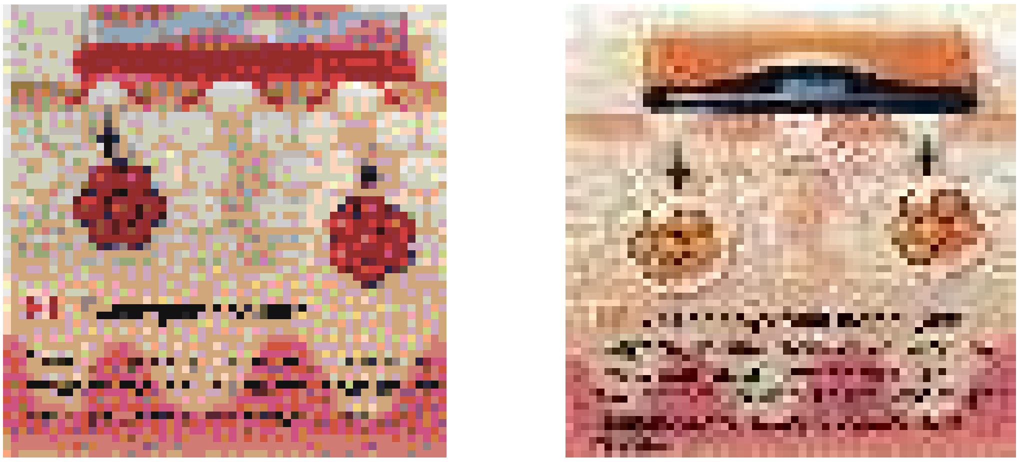


Figure 1: Membrane plasters used in medicine

The use of membranes for different purposes in the water and wastewater treatment is also well known. In Fig. 2 it can be seen how a typical membrane works in the case of filtration.

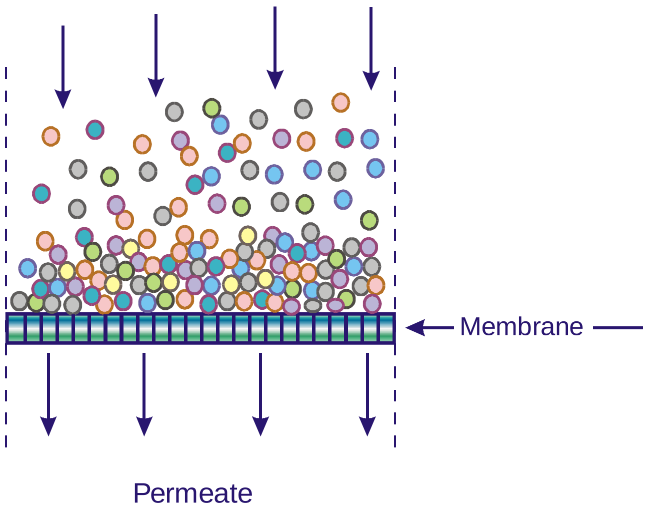


Figure 2: Filtration membrane

Membranes can be used for dosing of gases and chemicals in the process of the reversive osmosis as well(Staude E., 1992).
The diffusion can be described with the Flick's lows:

$$Ji = Di.\ \partial Ci/\partial x,$$

$$\partial Ci/\partial t = \partial/\partial x(Di.\partial Ci/\partial x),$$

$$q = F.C_o.e^{-kt}, \quad (g^{FeCL3}/m^2h)$$

LABORATORY STUDIES

A laboratory devicefordeterminingthecharacteristics of the membranes used for permeability of different substances is shown on Fig.3.

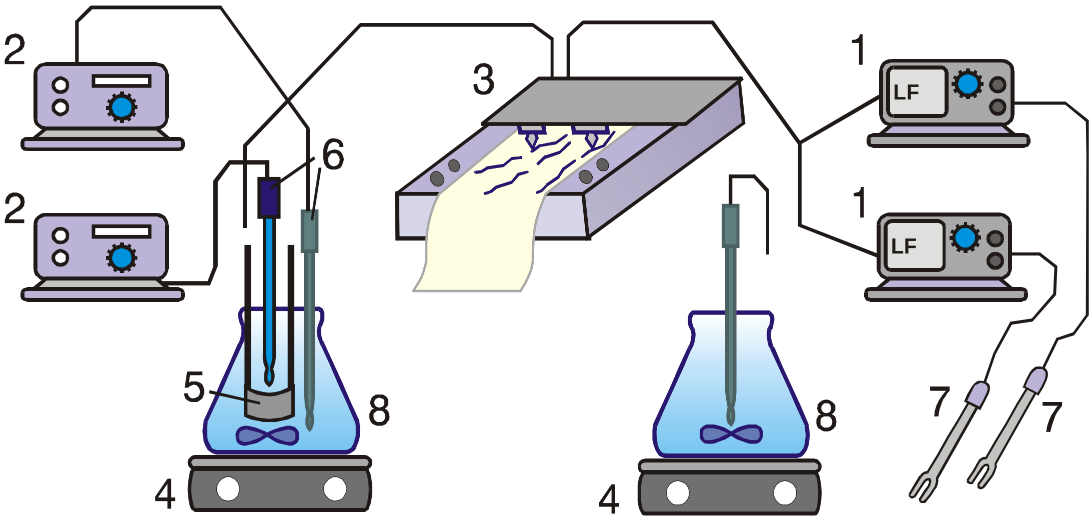


Figure 3: Experimental device- 1-conductivity meter; 2- pH-meters; 3- recorder; 4 – stirers; 5- membranes; 6,7 – electrodes; 8-erlenmayer flask

The permeability is depending of the following parameters:

- Diameter of the membrane pores, d_0;
- Reagent concentration,C;
- Membrane surface,S;
- Volume, V;
- Temperature;
- Renewal of the surface layer.

The membrane permeability was investigated in several examples.

The data after dosing of $FeCL_3$ through a polycarbonate membrane are presented on Fig.4 and Fig.5.

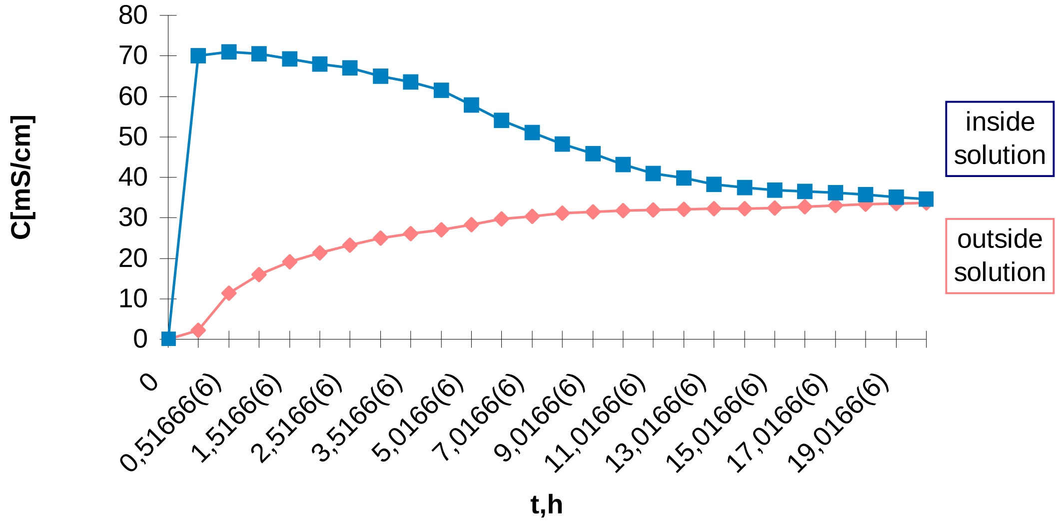


Figure 4: Variation of the conductivity with time when dissolving 100 ml 12% solution of $FeCl_3$ in 300 ml distilled water through a polycarbonate membrane (d_o = 0,4 µm; S = 7,5 cm^2)

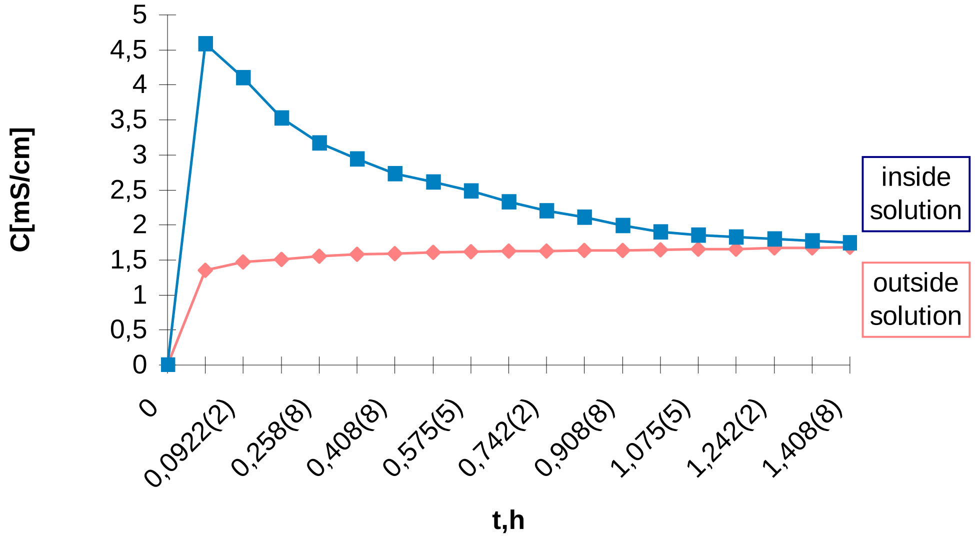


Figure 5: Variation of the conductivity with time when dissolving 100 ml 25% solution of $FeCl_3$ in 300 ml distilled water through a polycarbonate membrane (d_o = 8 µm; S = 7,5 cm^2)

The statistical modelling of the system (Simeonov V., 1997)allows to fix not only the most appropriate conditions for keeping the optimum dosage /through investigation of the mentioned parameters/ but to create a mathematical model of the proposed method. A full factor experiment of the type 2^n /power n/ planning was chosen for the purpose.

$Y = a_o + \Sigma a_i X_i + \Sigma a_{ij} X_i X_j$

Every incoming factor (X_i,X_j) is related to the out coming function by a corresponding regressive coefficient (a_o,a_i,a_{ij}) of the created regressive equation.

To be able to compare different groups of experiments and to achieve an adequate evaluation of different factors' influence a measurement of the value of the incoming function (Y) (the difference between C of the distilled water and C of the solution in the membrane device) was made after a substantially long period of time up to reaching a balance.

POSSIBLE APPLICATIONS

The simplest device (Fig. 6) can be a canister with chemicals closed with a definite dosing membrane. The canisters are floating in the reactor and spreading the chemicals in the bulk. The used chemicals are provided for a constant gradient and with a corresponding to it constant uninterrupted transport through the membrane.

This method is distinguished for its high flexibility, because it can be applied without any additional complications of the existing installations. It offers a simple and a very practical supplement or an overall substitution of the existing dozers.

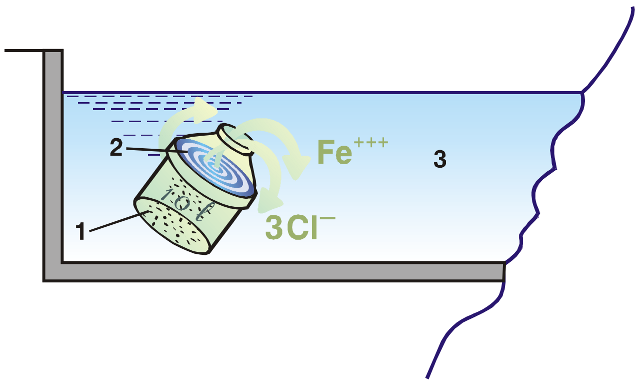


Figure 6: Model scheme of a dosing device /a single canister, which can be used in sudden pollutions, for precipitation, neutralizations etc./ - 1 – solution of $FeCl_3$; 2 – membrane; 3 – reaction basin

To enlarge the better possibility of exchanging the surface layers we developed the systems given in (Fig. 7 and Fig. 8).

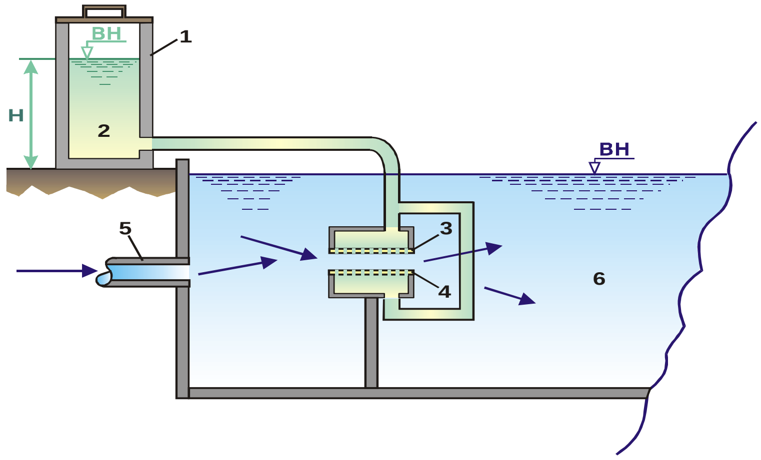


Figure 7: Dynamic dosing membrane device /with head pressure in the reagent container/ - 1 – reagent container; 2 – chemical reagent; 3,4 – membranes; 5 –inflow; 6 – reaction basin

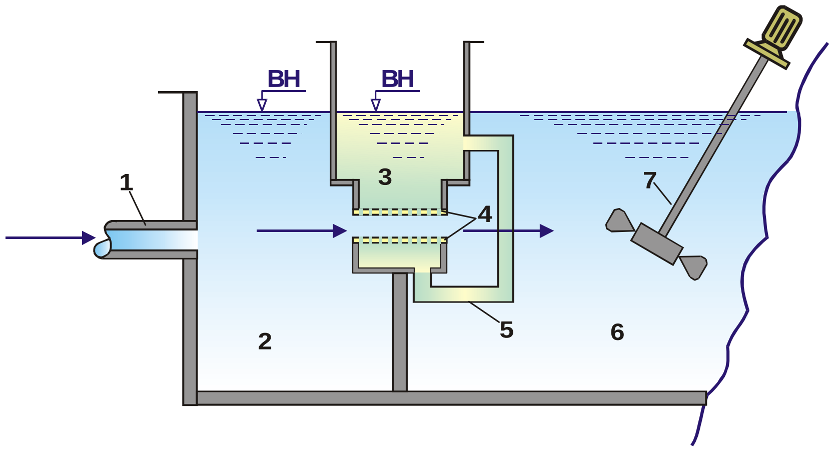


Figure 8: Dynamic mambrane dosator /witout pressure in the reagent container/ - 1 – inflow; 2 – entrance basin; 3 – reagent container; 4 – membranes; 5 – conecting pipe; 6 – reaction basin; 7 - mixer

These examples ilustrate some ideas of possible membrane dosers in cases when it's necessary to provide the chemical constantly depending on the incoming water quantity.
If a higher quantity of chemicals have to be dosed instead of membrane seaves with small openings can be used.

The general advantadgies of the membrane dosers are:

1. Low risk of overdosage;
2. Possibility of gradual increase of the dose until the optimum function is achieved;
3. No power consumption;
4. Posibility to provide the chemical from 2 or more points;
5. Easy service and exploatation;
6. Lack of moving machanical parts and noise.

CONCLUSIONS

The following conclusions about the statistical modeling of the system are made:

1. Non-linear relation between the function Y and used incoming parameters is available;
2. The regressive coefficient, determine d_0 /diameter of the membrane pores/ is positive in the most cases, which means that a higher level of d_0 is recommended to achieve the necessary effect;
3. The effect of membrane surface /S/ is of a secondary importance and a higher S values are recommended for a bigger mass-transport;
4. Reagent concentration /C/ is the most important parameter expressed by the high values of the relevant coefficient in all models;
5. A definite evaluation of the solution volume /V/ influence is difficult to make in the investigated cases. As long as V actually reflects on the hydrostatic pressure its influence on the final effect will increase when d_0 increases.
6. Some of the factors being of little importance /S, V/ as independent variable quantities in different cases when combined give a synergetic effect.
   This proves again that membranes should be recognized as a complex factor – combination of d_0 and S, and the membrane devises as a system influenced by C and V.

It is possible to use these membrane dosing devices for chemicals used in water and wastewater treatment.
The great advantage of the membrane dozers to match with different exploitation needs, their low investment coast and the lack of both moving parts and the necessity of electricity, which is well favorable to their wide usage in practice.

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