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THE WET DEPOSITION OF INORGANIC ATMOSPHERIC COMPOUNDS ON TO THE SURFACE OF THE LAKE FERTO

As it is well known, there is a continuous material transition between the spheres of the Earth. This stands also for the atmosphere and hydrosphere, i.e. several substances can enter the hydrosphere from the atmosphere, and vice versa.

The interaction of the main constituents of the atmosphere /nitrogen, oxygen etc./ with the water surface is well known.These substances exist in the air in very large quantities, thus human activities can influence their concentrations only slightly or not at all.
This is not valid for the trace constituents, namely for the trace gases and aerosol particles.These substances have very low concentrations in the air but at the same time they may have significant effects on the physical condition of the atmosphere. The trace constituents are very variable both in space and time and human activities can have significant influence on their quantities in the atmosphere.
The trace constituents get into the atmosphere partly in natural, partly in anthropogenic ways. The most important natural source is the biosphere supplying several trace gases/ e.g. NH_3, NO, H_2S, CH_4, N_2O etc/ while the ground and water surfaces are emitting aerosol particles/ calcium of soil origin, sea salt etc./into the air through dispersion.
In addition to the natural sources, however, the anthropogenic emission plays also a significant part. Its effect may be higher compared with that of the natural sources, especially in directly polluted areas.
The most important anthropogenic sources are: industry/factories, power plants/, transport/vehicles/, home keeping/ heating/ and

agricultural activities/ fertilizers, live stocks/. Due to these sources significant quantities of nitrogen dioxide, sulfur dioxide, and many other pollutants get into the atmosphere.

The trace gases of natural and anthropogenic origin leave the atmosphere due to the washout effect of precipitation/wet deposition/ and the turbulent diffusion/ dry deposition/. A certain portion of atmospheric trace gases transforms to particles by several chemical and physical processes. The particles formed from dispersion and gas-to-particle conversion deposit to the surface by wet and dry deposition.

Under the circumstances characteristic for Hungary the deposition of the trace constituents takes place mainly by washout effect of precipitation (HORVATH, 1980,a). Therefore our attention has to be concentrated on this problem. The question arises: what the effect of the trace constituents falling from the atmosphere on the hydrosphere is. This problem is not a new one: works in this connection are carried out all over the world. As a result it was shown eg. that the acidification of the rivers and lakes in Southern Scandinavia by the diversity of fishes, is due mainly to the industrial sulfur dioxide and nitrogen dioxide emission in Western Europe.

The eutrofication of lakes can be partly connected with the man-made air pollution and the deposition of pollutants. This is due to the fact, that the atmospheric substances getting into the hydrosphere increase the nitrogen and phosphorus content of the water. This can lead to an augmentation of the aquatic vegetation. For example, in the U.S.A. it was established (GOLLOWAY and COWLING, 1978) that in lakes with unpolluted catchment areas the nitrogen and phosphorus constituents are supplied mainly by precipitation. This problem arose in Hungary, namely in connection with the eutrofication of the Lake Balaton. It was demonstrated (MÉSZÁROS et al., 1980) that every year 604 tons of nitrogen compounds (expressed in N equivalent) and 64 tons of phosphorus compounds (expressed in P equivalent) get into the lake from the air. Out of this, 445 tons N and 57 tons P is due to the wet deposition i.e. the precipitation. According to rough estimations, in the case of Lake Balaton the effect of the air amounts to about 1/4 of the total effect of all the sources.

So it can be seen that the trace constituents of air (the significant part of which is due to the human activity) can exert a pernicious effect when getting into the hydrosphere. In the case of a given lake it can happen that the natural self-purifying processes are not able to compensate the polluting effects originating from different areas, leading thus to the upsetting of the biological equilibrium of the lake. Therefore there is a relation between the anthropogenic air pollution and the devastation (eutrofication and acidification) of lakes.

If we want to know how the water quality of the Lake Fertö is influenced by the wet deposition we are facing a double problem. First we have to determine the quantity of inorganic compounds (ions) getting into the lake during an unit of time. The other task is to compare the effect of the air with that of all the sources as there are rivers, streamlets, shore flows etc.

To make the comparison mentioned above is not our task.For determining the wet deposition of atmospheric compounds, however, we have applied several methods which proved during the investigation of the Lake Balaton.

In order to determine the rate of wet deposition one has to know, first of all, the chemical composition of precipitation water, i.e. the concentration of different inorganic ions (c_i) and the amount of precipitation water collected during a given time unit (p). The product of these two values gives the rate of the wet deposition of the i-th ion.

$$d_i = c_i \cdot p$$

Expressing the concentration in mg/l and the precipitation amount in mm/month units the deposition will be expresses in mg/m^2. month units. Examinations are generally carried out on precipitation water collected during monthly sampling periods. In order to determine the concentrations of several ions we have to collect the monthly precipitation samples. This procedure differs from the method applied in meteorological networks in two aspects. On the one hand the collection bottle an funnel should

seen in Table I. together with the weighted concentrations concerning to the 1978-80 years. For the complex ions the values are expressed in S, N and P equivalents. The total nitrogen rates were determined as the sums of those of the ammonium, nitrate and nitrite ions.
From Table I. it can be seen that though in the winter half-year the concentrations are much higher, owing to the lower precipitation amounts the values of deposition in the summer and winter half-years are same. Only the calcium and ortho phosphate ions originating from soil dispersion are the exceptions because their wet deposition rates are more significant in summer. The soil dispersion, namely, depends considerably on the moisturecontent of the soil which is generally lower in sommer. On the other hand during a certain period of the winter-half-year the snow-cover keeps the particles of soil origin from getting into the atmosphere. In addition, it must be also taken into consideration, that fertilizers are generally applied in the summer half-year. This affects the wet deposition of phosphate particles originating from the fertilizers. The deposition of other trace constituents of biological and anthropogenic origin is practically the same concerning the winter and the summer half-years.
In order to determine the quantity of trace constituents falling into the lake from atmosphere the deposition values have to be concerned to the whole surface of the lake. The rate of the annual deposition onto the Lake Fertö is found in the last column of Table I., expressed in ton/year units. The surface of the lake was taken equal to 280 km^2. As it can be seen the rate of the annual wet deposition of the N and P compounds (they are very important substances from point of view of eutrofication) amounts to as much as 263 tons N/year and 3,4 tons P/year concerned to the surface of the lake. It should be mentioned here that the analysis of phosphorus compounds was carried out only for the ortho-phosphate. In contrast to the mentioned Balaton investigations (MÉSZÁROS et al., 1980) the total phosphorus content of the precipitation water was not determined. According to the results of the Balaton investigations the concentration of the total phosphorus is higher than that of the ortho-phosphate by one order of magnitude.

be made of a material that does not get into chemical reaction with the sample (e.g. polyethylene, stainless steel, glass, etc.) and purity requirements must be striktly kept. On the other hand the sampling device must be chosen so that it should keep the collector closed when the weather is dry. In this way the effect of the dust of soil origin, the dry deposition of atmospheric compounds and the effect of other kinds of pollution can be eliminated.
According to several investigations (HORVÁTH, 1980, b) the concentrations in precipitation water collected by means of automatic collector are generally much lower as compared with the results of open collectors.
The operation of the automatic collectors is based on the following principle. The precipitation drops falling onto the sensing head of the collector closes a circuit due to what an electronic control device opens the top of the collector by means of an electromotor permitting thus the precipitation to get into the sampling bottle. After the precipitation has stopped and the sensing head has got dry (generally in few minutes) the circuit breaks resulting in closing the collector.
In the Hungarian precipitation chemistry network several wet-only collectors are already operating among others also near the Lake Fertő at Fertőrákos.
In the following, a short description of the results obtained by means of the data concerning to the Fertőrákos is presented.
In 1978, some hundred meters from the lake an automatic collector was set up at the Hydrological Observatory. Monthly precipitation samples were collected and analyzed for pH, electrical conductivity, Na^+, K^+, Mg^{2+}, Ca^{2+}, NH_4^+, Cl^-, SO_4^{2-}, NO_3^-, NO_2^- and PO_4^{3-} (As for the analytical methods see: KOZAK and MESZAROS, 1971). Knowing the monthly concentrations as well as the monthly precipitation amount, the monthly wet deposition was calculated in mg/m^2/month units. Then, from the monthly depositions, the rate of the wet deposition for the whole year, for the winter half-year (1 Oct. - 31 March) and for the summer half-year (1 Apr.-30 Sept.) was calculated. These data are to be

Table I

component	concentration			wet deposition			
	winter	summer	year	winter	summer	year	
	mg/l			mg/m^2.halfyear		mg/m^2.y	t/year
Cl^-	1.28	0.72	0.90	246	300	546	153
SO_4^{2-}-S	2.42	1.10	1.52	464	455	912	255
NO_3^- -N	0.90	0.49	0.62	173	201	374	105
NH_4^+ -N	1.32	0.75	0.93	254	308	562	157
NO_2^- -N	0.02	0.01	0.01	3	3	6	2
total N	2.24	1.25	1.56	430	512	942	263
Na^+			0.39			239	67
K^+			0.24			147	41
Mg^{2+}			0.37			225	63
Ca^{2+}	1.89	1.70	1.76	362	703	1065	298
PO_4^{3-} -P	0.02	0.02	0.02	3.2	9.0	12.2	3.4
pH	5.2	5.7	5.5.				
$\varkappa_{18}$ (μScm^2)	39	24	28				
p (mm)	192	414	606				

Table I: The mean (weighted) concentrations of precipitation water, the mean pH, electrical conductivity $\varkappa_{18}$ (μScm^2) precipitation amount (p) and the wet deposition rates at the Lake Fertő on the basis of Fertőrakos data concerning to 1978-80 years.

Though only a certain portion of the total (soluble and insoluble) phosphorus is available for the vegetations its measurement may, however, provide useful information. In the future, therefore, works will be carried out in this field.

The annual deposition rates of nitrogen compunds and ortho-phosphate falling into the Lake Fertő can be compared with those for Lake Balaton (445 t N/year and 2 t P/year, respectively).

Taking into account the difference between the surface of two lakes (surface of Balaton being about 2,1 times larger) there is a good agreement in the case of nitrogen compunds while the rate of deposition of ortho-phosphate is 3-4 times higher for the Lake Ferto. This permits to conclude that here local fertilization has a more important effect.

Finally, examining the pH values in the Table I. It can be stated that the mean pH value approximates the equilibrium value of 5,6 controlled by the atmospheric carbon-dioxide. Thus acidification of atmospheric origin is not threatening the lake. (It should be noted that in Northern Europe the pH values of precipitation waters are often lower by two pH units, which means a hundredfold increase in the concentration of hydrogen ions).

Thus it can be stated that similary to other lakes significant quantities of inorganic trace constituents are deposited onto the surface of Lake Fertő. The nitrogen containing gases released in distant areas (eventueally several 1000 km-s from the lake) as well as the particles originating from them getting into the lake may take part in its eutrofication. The phosphorus compounds which in addition often appear as a minimum factor from the point of view of the growth of aquatic vegetation are sooner of local origin. Namely, there are no stable phosphorus compound in gas phase.

At the same time, the so-called giant phosphorus particles with a radius higher than 1 μm originating from soil dispersion due to their significant gravity deposition are not able to get to farther areas in contrast to the gases and the particles originating from the gas-to-particle conversion the radius of which generally does not reach to 0,1 μm.

Finally, it can be stated that the wet deposition of the inorganic atmospheric compounds onto the Lake Fertő has been determined. The next task is to detect the rate of their quantity as compared to the other sources, in other words, to determine whether the wet deposition of the atmospheric trace constituents plays as considerable part in the eutrofication of the lake. This is, however, the task of hydrologists.

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