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ANDRZEJ BUSZMAN,* JERZY KWAPULIŃSKI,*
WŁADYSŁAW KLIMCZAK*, EDWARD WŁODYGA*

ON SOME PROBLEMS OF SURFACE WATER POLLUTION WITH BERYLLIUM

The paper deals with the problem of migration of beryllium to surface water, caused by atmospheric precipitation and infiltration from soil. The equations describing the participation of atmospheric precipitation and infiltration from soil of the given catchment area in the process of water loading with beryllium have been established. The effects of water mineralization, give of catchment area and of its unitary outflow on variations in beryllium concentration in water, as well as the changes in beryllium contents in atmospheric precipitation in rural and industrial areas, depending on chages in its mineralization and the total annual precipitation have been also discussed.

1. INTRODUCTION

Beryllium enters the natural environment mainly with fly ashes produced during coal combustion. Polish power coals contain various amounts of beryllium compounds, generally not more than 6 g of Be per ton of coal. There are, however, some coal beds containing 10 g of Be/t. Besides, beryllium is also washed-out of slags and other non-volatile ashes from power stations, being stored on dumping grounds. Beryllium also enters the atmosphere with power station dusts that remain in the atmosphere for some time depending on the meteorological and topographical conditions of a specific place. The deposits of granite rocks as well as hard coal [3], brown coal [7] and oil [5] deposits have been found to contain relatively great amounts of beryllium.

In the atmospheric air in industrial regions the content of beryllium is higher. The air in Polish cities contains relatively great amounts of toxic beryllium [4] in comparison with other cities. Beryllium which, with dusts and vapours, enters the human body through the respiratory tracts causes serious diseases. A significant correlation has been observed between its content in the air and the frequency of lung-cancer occurrence [8], [9].

In Katowice and Zabrze the beryllium concentration in the air, equal to about 0.7 ng/m^3, is higher than in other European cities cf. Belfast — 0.11 ng/m^3, Dublin — 0.04 ng/m^3, Helsinki — 0.13 ng/m^3, Oslo — 0.08 ng/m^3, Liverpool — 0.59 ng/m^3, Hamburg — 0.5 ng/m^3.

According to JUST and KELLUS [4] who have examined the beryllium concentration in the air in a number of Polish cities no variations with seasons are observed in the cities of Silesia region. Whereas in Kraków, Warszawa, and Wrocław the beryllium concentration is found to be higher in the winter than in the summer.

The self-purification of the atmosphere is most effective during precipitations. Hence,

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* Research Institute for Environment Protection, Katowice, Poland.

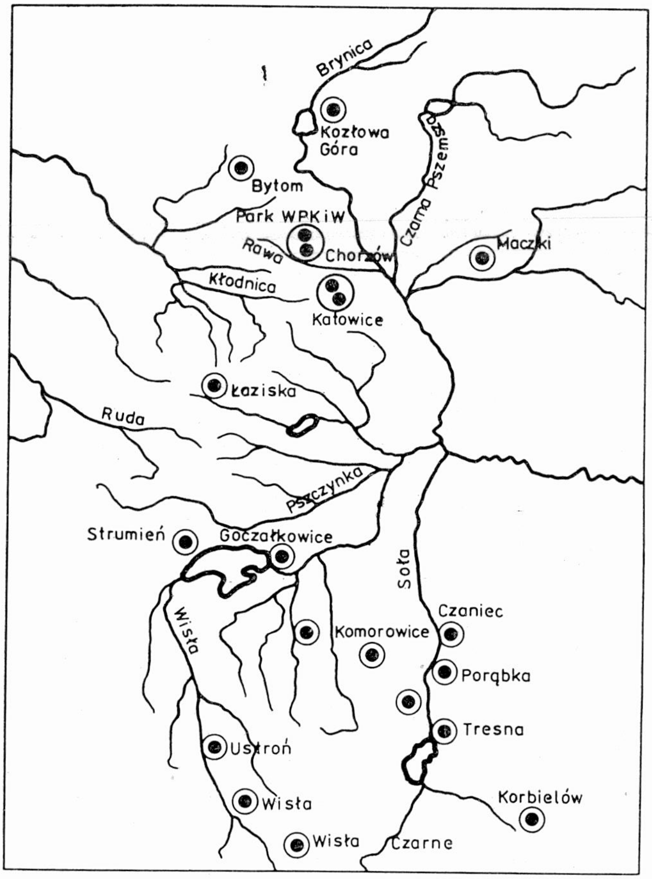

Fig. 1. Distribution of sampling stations
Rys. 1. Rozmieszczenie punktów poboru prób

the investigations aiming at determining the role of precipitations as the air cleaning agent turn out to be of great importance. There are no literature data either on the occurrence, displacement, or accumulation of beryllium in the environment or on the sources of the environment pollution with this element. That is why in the years 1968—1975 we carried-out the complex studies of the pollution of natural environment of the Katowice region with beryllium.

Results concerning the problem of surface water pollution with the element in question are given in this paper.

2. DETERMINATION METHODOLOGY

Beryllium was determined in the examined samples by two parallel methods, the spectrographic method and the atomic absorption one, in order to obtain reliable results. In the former method a Carl Zeiss Jena spectrograph of medium dispersion Q-24 was applied. The conditions of the spark excitation were the following: inductance 60 μH, capacity

10 μF, resistance 0Ω, current intensity 6 A — direct current, broken arc. Each sample was excited three times, each time for 20 s. The detectability of beryllium with this method was of the order of 0.01 ng/dm^3.

The beryllium content in the samples was determined basing on the standard curve showing in the logarithmic system the change in beryllium concentration vs. the opacity difference. In order to draw the curve, a matrix of the mineral composition similar to that of the examined samples was made. The appropriate amounts of beryllium were added to the matrix. The opacity difference was determined by the photometry of spectral lines at the wavelength of 312.5 nm obtained separately for the sample and standard.

Since the geometry of measurements of the beryllium content in samples and standards was kept constant, the systematic error was the smallest one. The results obtained differed from the average obtained from six single measurements by about 8%.

The beryllium content was also determined by the atomic absorption method, by means of an AA-5 set produced by the VARIANTECHTRON firm [1].

The method was sensitive to 0.17 $\mu g/cm^3$ and the limit of detection was equal to 0.002 $\mu g/cm^3$. The measurements were performed by applying the reducing acetylene-nitrous oxide flame and at the wavelength of 234.9 nm, the lamp current of 5 mA, and a gap of 0.5 mm.

The results obtained in the atomic absorption method differed from the average obtained from six single measurements by about 10%. The results obtained by the both methods differed by 3–20%, on the average by 11%.

3. RESULTS AND DISCUSSION

3.1. BERYLLIUM CONTENT IN SURFACE WATER

The content of beryllium in surface water in function of its mineralization is presented in fig. 2. The relation is illustrated in a logarithmic–logarithmic system by a straight line, the equation of which is of $y = a \cdot x^b$ type. The analysed factors are strongly correlated what is expressed by the correlation coefficient

$$r = 0.84 \pm 0.06.$$

The correlation significance was tested by:

$$t = \frac{1}{2} \ln \frac{1+r}{1-r} : \frac{1}{\sqrt{n-3}}. \tag{1}$$

The value of t coefficient is much greater than 3, what is both necessary and sufficient to consider the relation in question significant.

The increasing beryllium concentration in water is described by two coefficients:

$$a = 0.0003 \text{ and } b = 1.542$$

which should be treated as the measures of the varying content of beryllium in water depending on its mineralization. The coefficient of variation in beryllium content in surface water is equal to 0.98±0.185 in industrial regions, and to 0.45±0.035 on recreational grounds. The beryllium content in water from industrial regions varies in a different way than in water flowing through recreational grounds, what is evidenced not only by the different coefficients of variation but also by the following data. Mean content of beryllium in surface water is equal to 12.9 μg/dm³ in industrial regions, and to 2.3 μg/dm³ on recreational grounds. The beryllium content in water varied from 5.9 to 34.2 μg/dm³ in industrial regions and from 2.9 to 6.2 μg/dm³ at the distance of 80 km from the Upper-Silesian Industrial Region (table 1). From the above-mentioned results it follows that:

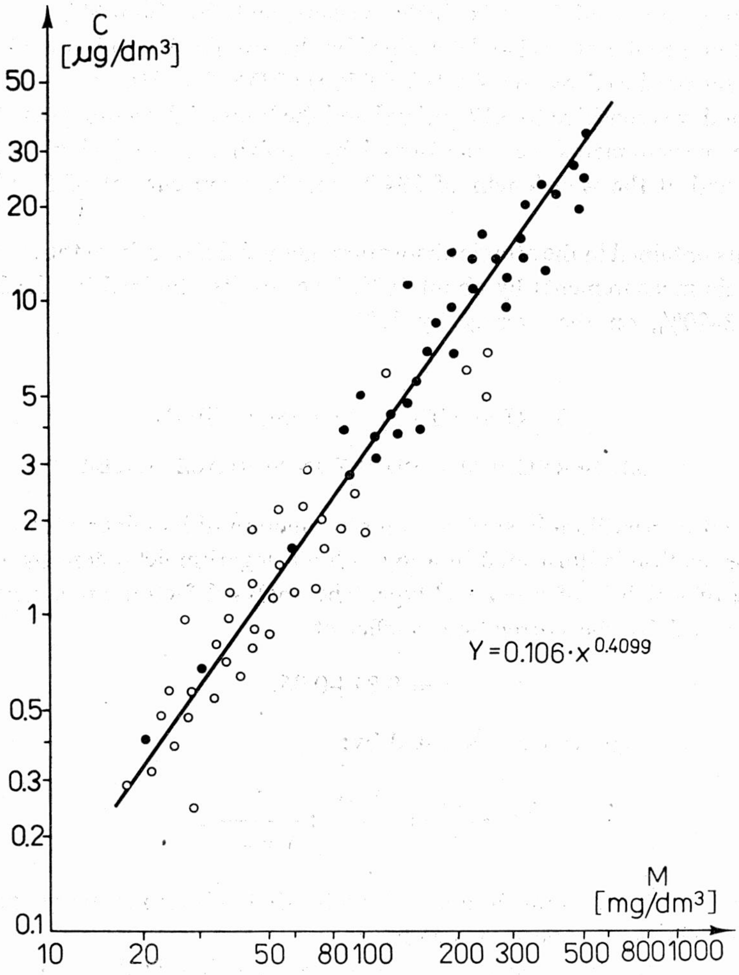

Fig. 2. Beryllium concentration (C) in water vs. its mineralization (M)

Rys. 2. Stężenie berylu (C) w wodzie w funkcji jej mineralizacji (M)

— the content of beryllium in mountain river waters is significantly lower than in waters of rivers flowing through industrial regions,

— in the case of mountain rivers the beryllium concentration in water is not conditioned by the size of the river basin e.g. in the S-Cz river, which has the basin of 1111.77 km^2, the mean content of beryllium is of the order of 3 μg/dm^3 and in the BRE river, having the basin of 85.67 km^2, of 2.4 μg/dm^3,

— generally, the content of beryllium increases with the increasing river basin size,

— the content of beryllium in water is conditioned by the way of the river utilization e.g. the waters of the G-U and P-U rivers having rather small basins (329 km^2 and 284 km^2, respectively) are characterized by a high and varying content of beryllium, 71.6 μg/dm^3 being the mean value for the G-U river and 306 μg/dm^3 for the P-U one.

Water from the river W contains only about 4 μg Be/dm^3.

Table 1

Occurrence of beryllium in water at selected stations on mountain rivers
Występowanie berylu w wodzie na wybranych stanowiskach górskich rzek

River	Range of changes μg Be/dm^3	Mean concentration μg Be/dm^3	River basin S km^2	Flow-rate q dm^3/s·km^2
S – P	0.5–2.7	1.4	1082.13	296
S – Cz	0.2–15.4	3.2	1111.77	285
Z – S	0.5–2.4	1.7	40.09	—
St	0.5–1.2	0.78	—	—
BRE	0.5–3.6	2.38	85.67	—
BI – U	3.9–13.7	7.45	144.46	640

In a small section, however, the concentration of beryllium may be changed, e.g. on August 12 the beryllium content in the river W measured at NB station and below the river P mouth amounted to 21.4 μg/dm^3 and 34.9 μg/dm^3, respectively.

The contents of beryllium determined in water from ponds situated in industrial regions are much higher, in comparison with water from mountain rivers, and generally exceed 20 μg/dm^3. The level of concentration is conditioned by the effect of a given branch of industry. Waters from the ponds situated close to the cement plants G and GO contain, respectively, 22 μg Be/dm^3 and 35 μg Be/dm^3, those from the mine pond — 52.9 μg Be/dm^3, from the pond formed by dumping grounds of a power station — 56–68 μg Be/dm^3, and the waters from the pond situated at the peripheries of the industrial centre and in the direction of wastewater flowing from the west contain 20–35 μg Be/dm^3.

In winter the pond water is naturally protected against the falling dusts by the ice cover. The results of determining the presence of beryllium in the ice provide an interesting comparative material for studying the possibilities of surface water pollution by the falling dusts and precipitations. The experiments were conducted for ice from reservoirs GOC and WAP and the ponds WPWK-3 and K-M (table 2).

From table 2, it follows that beryllium concentration in the ice from ponds in the industrial region is higher than in ponds situated at a greater distance from the pollution centre. The upper layer of ice, being directly exposed to dusts was found to contain 10.8 µg Be/dm^3 in GOC reservoir, 7.4 µg Be/dm^3 in WAP reservoir, 19.8 µg Be/dm^3 in K-M reservoir and 13.6 µg Be/dm^3 in WPWK reservoir. The distribution of beryllium in the ce cross-section is similar to that for ^{90}Sr [6]. Worth mentioning is also the fact that the atio of the beryllium concentration on recreational grounds to that in industrial regions s of the same order as the ratio of the changes in quantities of dust precipitations falling in these areas. The ice layers lying more deeply contain smaller amounts of beryllium, whose concentration in the layer that contacts with water is conditioned by its concentration in water. Waters from the reservoirs GOC and WAP contain smaller amounts of beryllium. The concentration of this element was then found to vary from 1.0 to 1.5 µg/dm^3.

Table 2

Occurrence of beryllium in snow cover

Występowanie berylu w pokrywie śniegowej

Station	Reservoir surface ha	Dust fallout q/m^2 month	Layer cm	Be µg/dm^3
GOC	3800	8.84	0–5	10.8
			5–10	3.2
WA	13	7.68	0–4	7.4
			4–8	2.8
KM	3	29.84	0–5	19.8
			5–10	7.4
Ch 1	3	25.8	0–5	13.6
			5–11	4.1
Ch 2	1	25.8	0–5	8.6
			5–8	8.2
Ch 3	1	25.8	0–4	14.5
			4–8	7.3

Basing on the analysis of the curve showing the changes of beryllium concentration vs. the river basin size (fig. 3) we may distinguish three ranges of these changes. Up to 200 km^2 a small increase of the beryllium background is observed, within the range of 200–750 km^2 the concentration increases more rapidly, and in the remaining section by jumps.

The course of the analysed curve is significantly conditioned by the degree of pollution of the river W and its tributaries. The curve ends at the cross-section of the river W in

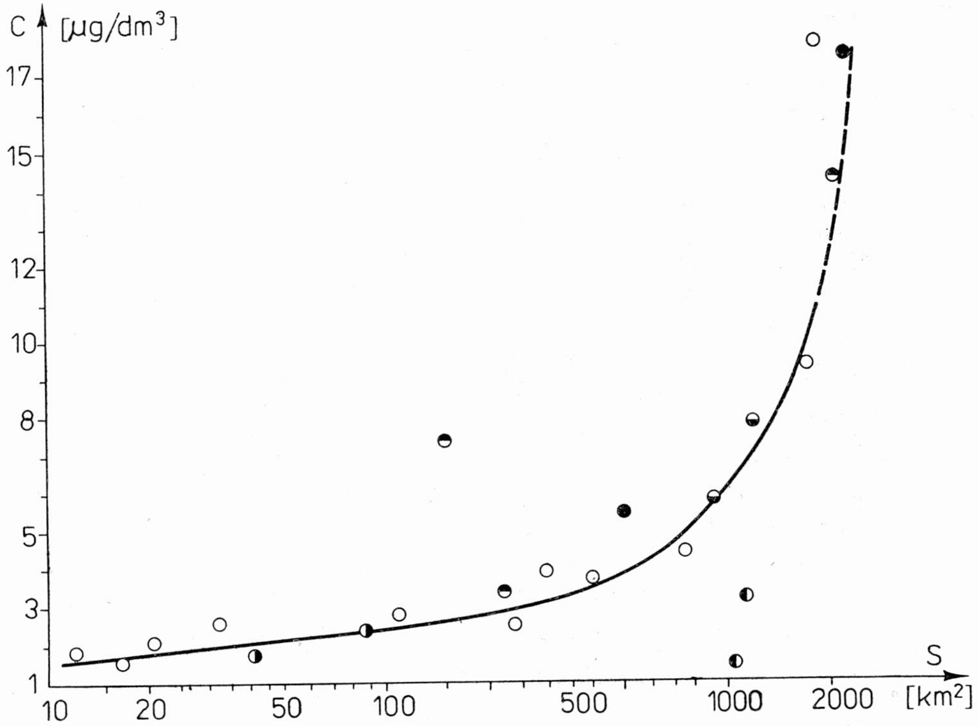

Fig. 3. Mean beryllium content in water (C) vs. the size of river basin (S)

Rys. 3. Średnia zawartość berylu w wodzie (C) w funkcji zlewni (S)

a rural place — 1754.67 km². Hence, the variation in Be concentration with the increasing river W basin would, supposedly, proceed according to the following scheme: increase in concentration — stabilization of the level — increase in concentration — stabilization of the level.

In section of "the stabilized concentration level" the river undergoes self-purification processes and small additional load of beryllium is observed.

Additional loads of beryllium, mixed with the river water through the tributaries with large basins and appropriate industrial infrastructure as well as by the effluents of proper chemical characteristics result in rapid changes of Be concentration.

The variation of beryllium background vs. flow-rate is shown in the normal system in fig. 4.

3.2. BERYLLIUM MIGRATION TO SURFACE WATERS

Of the various ways by which beryllium enters surface waters most important are precipitations and infiltration from soils. Their contributions to the river pollution with beryllium are different and may be established, according to GŁOWIAK [2], by analysing the relation

$$C_w = K_0 \cdot C_0 + K_q \cdot C_q, \tag{2}$$

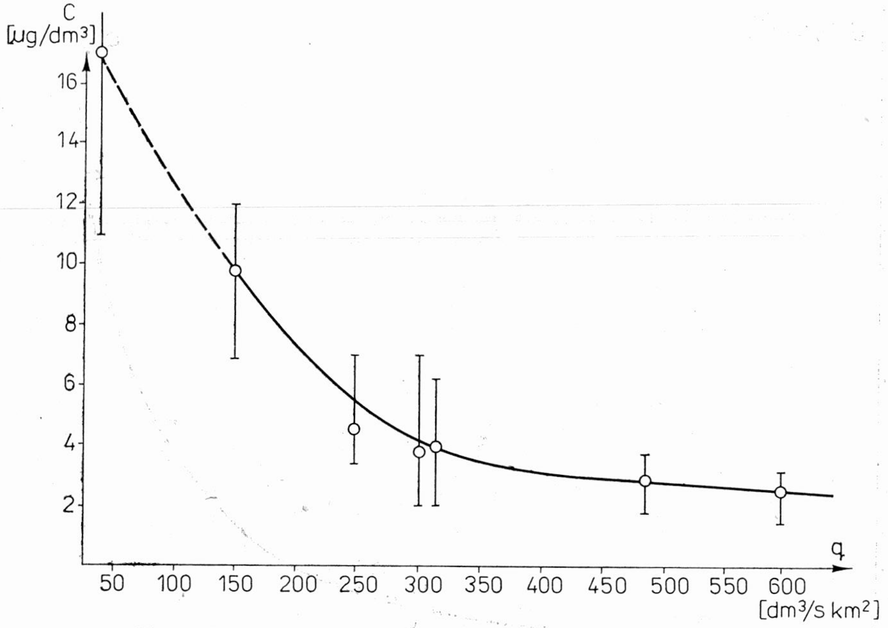

Fig. 4. Mean beryllium content in water (C) vs. flow-rate (q)

Rys. 4. Średnia zawartość berylu w wodzie (C), w funkcji spływu (q)

where C_w is the element concentration in water µg/dm³, C_0 is the element concentration in precipitation µg/dm³, C_q is the element concentration in soil close to the river bank, µg/dm³. The coefficients K_0 and K_q denote the contributions of the respective ways of the beryllium penetration into water from precipitations

$$K_0 = \frac{F \cdot f_0}{V} \tag{3}$$

and from soil

$$K_q = \frac{F \cdot t_q}{V}, \tag{4}$$

where F is the surface of the river basin, km², V is the monthly river flow, km³/month, f_0 is the part of the total content of a given element, coming from precipitations, and t_q is the part of the total content of a given element, coming from soils close to the river banks and from the river bottom.

By means of successive transformations we obtain

$$\frac{C_w}{C_0} = \frac{C_q}{C_0} K_q + K_0. \tag{5}$$

To answer the question concerning the amounts of a given element coming either from precipitations or from water we must analyse the plots shown in fig. 5 and illustrating the relation

$$\frac{C_w}{C_0} = f\left(\frac{C_q}{C_0}\right). \tag{6}$$

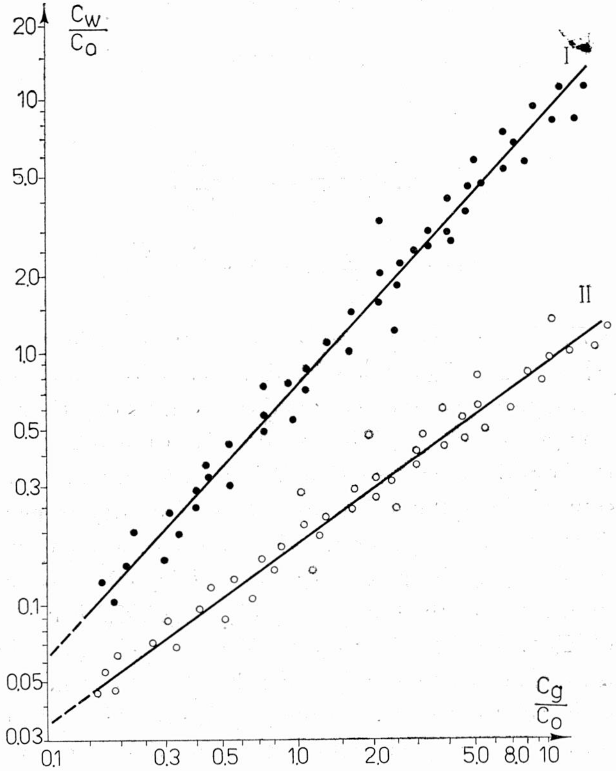

Fig. 5. Contribution of precipitations and soil to surface water pollution with beryllium in the Upper-Silesian Industrial Region (I) and on recreational grounds (II)

Rys. 5. Udział opadów atmosferycznych i gleb w procesie obciążenia wód powierzchniowych berylem na terenie GOP (I) i na terenach rekreacyjnych (II)

From the results obtained by **Głowiak** and co-workers [2] it follows that the main source of changes in ^{90}Sr and ^{137}Cs content are the precipitations.

The predominance of either one or the other source of surface water pollution is conditioned by the local situation. Worthy of notice is also the contribution of precipitation and soil to the enrichment of surface water chemical composition with the elements whose quantities in the environment are greater than those in the river basin, being ensured by geochemical equilibrium.

Beryllium enters the natural environment with the fly ashes resulting from the coal combustion in power stations. The content of beryllium in fly ashes varies from 10 to 20 μg/g [7].

The amount of beryllium falling to surface unit (S/km^2) is strongly correlated with its content in precipitations. In turn, due to the increase in the falling beryllium its content in soil increases as well. Hence, there are two serious sources of the hydrosphere pollution with beryllium.

The migration of beryllium to water in industrial regions (I) and on recreational grounds (II) is illustrated by a straight line of the equation

$$y = ax + b, \tag{7}$$

where

$$y = \frac{C_w}{C_0}, \quad x - \frac{C_g}{C_0}, \tag{8}$$

$$a = \log \frac{C_w}{C_g} \quad \text{and} \quad b = \log \frac{C_w}{C_0}. \tag{9}$$

The value $a = K_q$ denotes the portion of beryllium contributed by soil to its total content in water, whereas $b = K_0$ denotes the direct contribution of beryllium from precipitations. From the comparison of the lines I and II it follows that the quantitative predominance of beryllium migration from soil is over that from precipitations. In places situated at a certain distance from the Upper-Silesian Industrial Region and due to a characteristic "wind rose" the course of beryllium migration to surface waters may be more complex and the resultant beryllium concentration is then lower in water from industrial regions. This is confirmed by fig. 6, e.g. in the case of a town lying 40 km (in a straight line) from the industrial centre the plot of the function $C_w/C_0 = f(C_g/C_0)$ is different and consists of two parts: when C_g/C_0 varies from 2 to 4 a rapid increase in the ratio of beryllium concentration in water to that in precipitations can be observed, whereas for C_g/C_0 greater than 4 the changes in concentration are similar to those observed in industrial regions. In the former case, an increase in beryllium concentration is mainly due to migration from soil, whereas in the latter case the concentration is conditioned by precipitations.

The straight lines obtained for recreational grounds are of similar course, being shifted more or less with respect to the resultant straight line. In the case of industrial regions, however, no family of straight lines was obtained. Observational data are placed close to one curve. Slightly different coefficients of the direction of straight lines illustrating the function

$$\frac{C_w}{C_0} = f\left(\frac{C_g}{C_0}\right) \tag{10}$$

were noted only for places situated in the north-west periphery of the Upper-Silesian Industrial Region.

The values of the coefficient K_g indicating the contribution of Be migration from soil, and the coefficient K_0 determining the migration of Be with precipitations, as well as the values of the ratio of one way of migration to the other K_0/K_g, the ratio K_{gp}/K_{gr} of K_g

coefficients in industrial regions (K_{gp}) and on recreational grounds (K_{gr}), and the ratio K_{0p}/K_{0r} of K_0 coefficients in industrial regions (K_{0p}) and on recreational grounds (K_{0r}) are all given in table 3.

From the data presented it follows that the contribution of Be migration from soil is 14 times, and with precipitations twice as large in industrial regions as on recreational grounds, and the contribution of precipitations in seperate recreational places may be

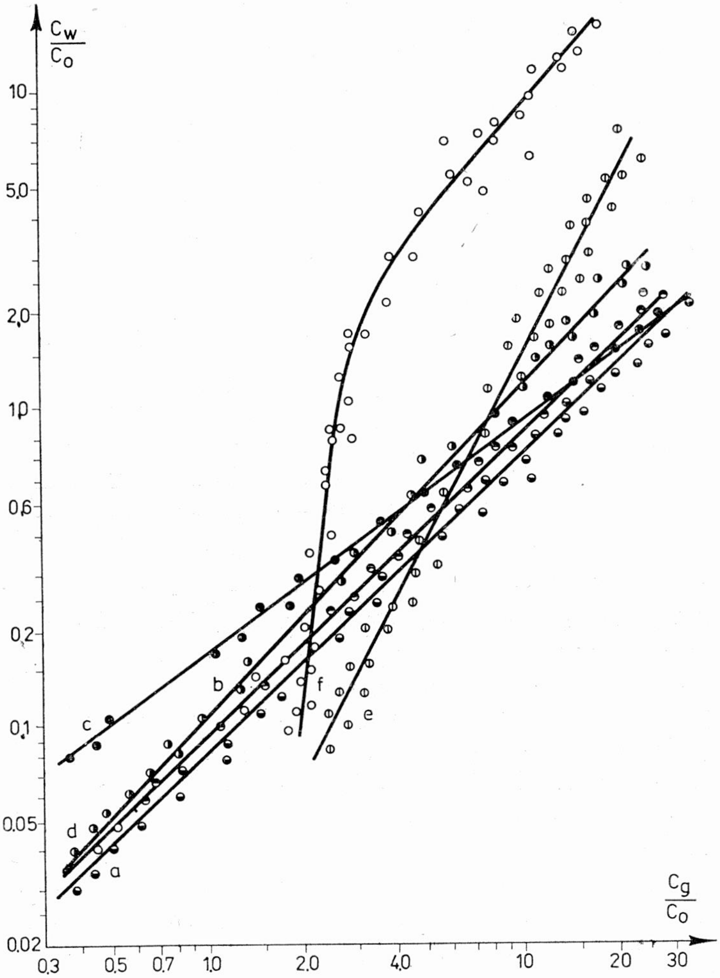

Fig. 6. Contribution of precipitations and soil to surface water pollution with beryllium in places laying at some distance from the pollution centre

KOB station (*a*), KOM station (*b*), MA station (*c*), WA station (*d*), ST station (*e*), GO station (*f*)

Rys. 6. Udział opadów atmosferycznych i gleb w procesie obciążenia wód powierzchniowych berylem na terenach położonych w większej odległości od centrum zanieczyszczeń

stanowisko KOB (*a*), stanowisko KOM (*b*), stanowisko MA (*c*), stanowisko WA (*d*), stanowisko ST (*e*), stanowisko GO (*f*) greater, e.g. about 7 times. In industrial regions the contribution of precipitations with respect to migration from soil is of the order of $6 \cdot 10^{-2}$, whereas on recreational grounds both the contributions are nearly equal. The value of $K_0/K_g = 0.523$ points at even slightly more important role of precipitations.

Table 3

Be migration to water with precipitations (K_0) and from soil (K_g)
Migracja berylu do wody poprzez opady atmosferyczne — K_0— i z gleby — K_g

Sampling place	K_g	K_0	$\frac{K_0}{K_g}$	$\frac{K_{g0}}{K_{gr}}$	$\frac{K_{0p}}{K_{gr}}$
Industrial regions — P	0.907	0.062	0.068	—	—
Recreational grounds — R	0.065	0.034	0.523	13.95	1.82
Station K — S	0.068	0.0095	0.139	13.33	6.52
Station G — Z					
I	1.0	I 10^{-2}	10^{-2}	—	—
II	1.97	II 10^{-5}	$5. 10^{-6}$	—	—

The beryllium transfer from soil to water is given by $K_g = 0.907$ for industrial regions and by $K_g = 0.065$ for recreational grounds. In the case of precipitations the respective values are 0.062 and 0.034. Basing on these results some generalizations concerning the ways of pollutants transport can be made. If they are carried from greater distances, then, similarly as in the case of ^{90}Sr and ^{137}Cs, the concentration of a given element is conditioned by precipitation [2]. If, however, the observations are carried out in the region of the direct emission of pollutants, then the concentration of a given element in water is, for a long time, conditioned by its load in the soil, being due to the so-called total fall out in this area.

A strong correlation between the analysed C_w/C_0 and C_g/C_0 values is described, for the Upper-Silesian Industrial Region and recreational grounds, by the positive coefficient of correlation equal to about 0.85. Since the value of significance criterion for the correlation is much greater than 3 the correlation is sensible.

In the areas with the increased quantity of one year's precipitations the mean content of beryllium is lower — fig. 7. By extrapolating a hypothetical straight line we obtain the value of 142.4 for one year's precipitations of 500 mm. Taking account of the climatic conditions prevailing in the observed area the quantity of one year's precipitations equal to 500 mm seems most probable to include trace precipitations. The value of 142.4 is interpreted as the highest beryllium concentration at the minimal quantity of precipitations. Practically, it may be assumed to be the quantity of beryllium washed out of the air during the first period of precipitation.

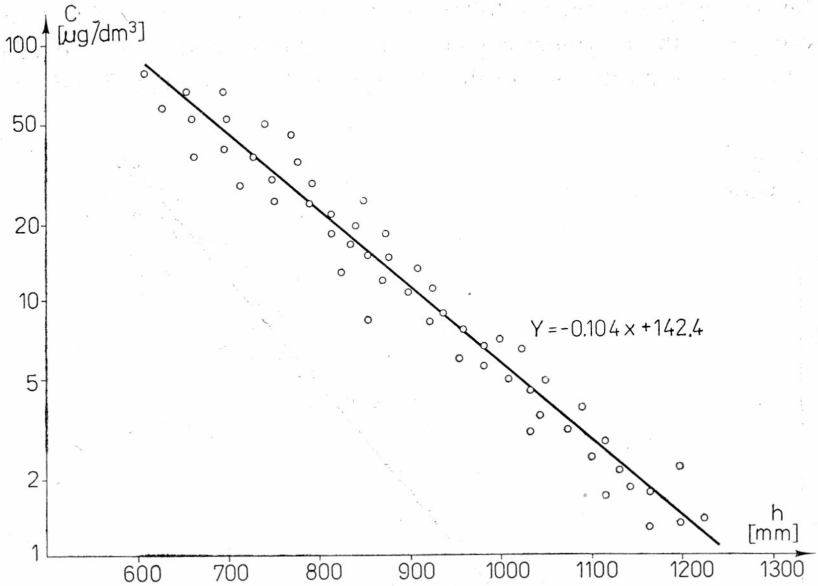

Fig. 7. Beryllium content (C) [μg/dm³] in precipitations vs. annual precipitations (h) [mm] in the years 1970–1975

Rys. 7. Zawartość Be (C) [μg/dm³] w opadach atmosferycznych jako funkcja rocznych sum opadów atmosferycznych (h) [mm] w latach 1970–1975

To test the accuracy of our approach we compared the beryllium concentrations in the so-called minimal precipitations expressed in μg/g and μg/dm³ at $b = 142.4$.

Assuming the same systematic error for the measurements of the beryllium concentration in the rain or snow of trace or longer duration the trace precipitations are supposed to wash out the quantity of beryllium proportional to the dustiness of the air. Under specific meteorological conditions it may be considered the initial quantity, which will be washed out and diluted during precipitations of much higher intensity in a specific area. Nearly the same results of measuring the beryllium concentration in μg/dm³ imply the existence of similar beryllium background in industrial region. Moreover, the values of beryllium concentration in μg/dm³ were found to differ from the value b in the above-mentioned equation by 6.75%, on the average. The mean concentration determined from 34 observations is equal to 145.8, the scatter varying from 124.0 to 170 μg/dm³. A small scatter of results is characteristic of sampling stations situated in industrial regions, what is obviously due to the highest level of air pollution as well as to the fact that the pollutants washed out of the air may be nearly simultaneously replaced with the fresh ones. Moreover, the value $b = 142.4$ for the Katowice district may be really considered a characteristic and basic quantity of beryllium being transported first during precipitations. Hence the first few minutes of precipitation are decisive as far as the quantity of beryllium transferred to the earth surface is concerned. During further precipitation the elution processes are accompanied by the dilution of pollutants.

From further analysis of fig. 7, it follows that in regions characterized by larger quantities of precipitation the beryllium content is lower due to a smaller load of pollutants and more effective self-purification of the atmosphere. Basing on figs. 8 and 9 the content of beryllium in precipitations seems to be directly proportional to their mineralization. To verify this supposition, two graphs exhibiting the relation considered were drawn in a logarithmic-logarithmic system. The course of changes is described by the following equations:

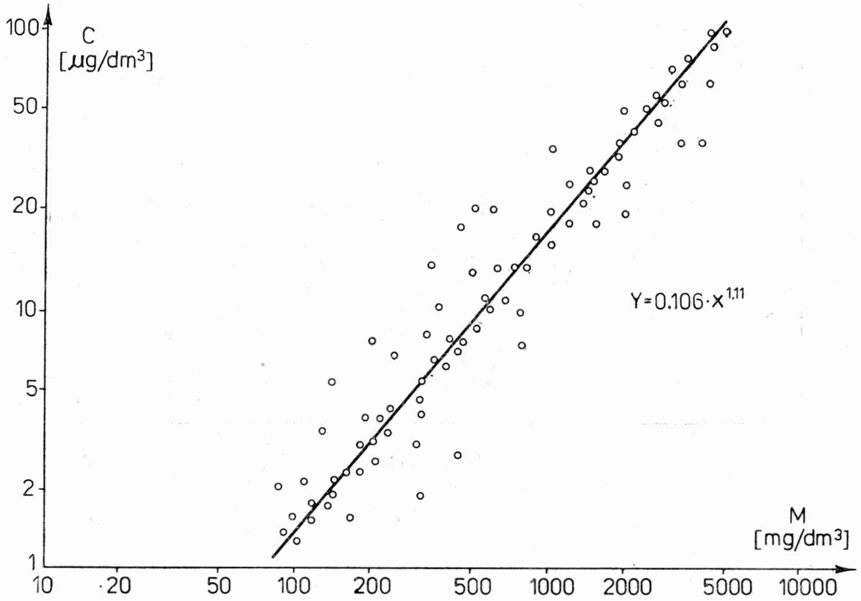

Fig. 8. Beryllium concentration (C) [μg/dm³] in precipitations in industrial regions vs. mineralization (M [mg/dm³] of precipitations

Rys. 8. Wpływ mineralizacji opadów atmosferycznych (M) [mg/dm³] na stężenie berylu (C) [μg/dm³] w opadach na terenach przemysłowych

for recreational grounds

$$y = 25.64 \cdot x^{0,1761}, \tag{11}$$

for industrial regions

$$y = 0.106 \cdot x^{1.11}. \tag{12}$$

In both cases the correlation coefficient indicating the degree of the beryllium cotnent dependence on the precipitation mineralization is very high and equals 0.85. The value of the criterion of the relation significance is much greater than 3. A strong correlation between the parameters in question was also confirmed by the analysis of the results of examining precipitations in industrial regions (125 observations) and on recreational grounds (91 observations). The equations derived allow to forecast the changes in beryllium content depending on the varying mineralization of precipitations.

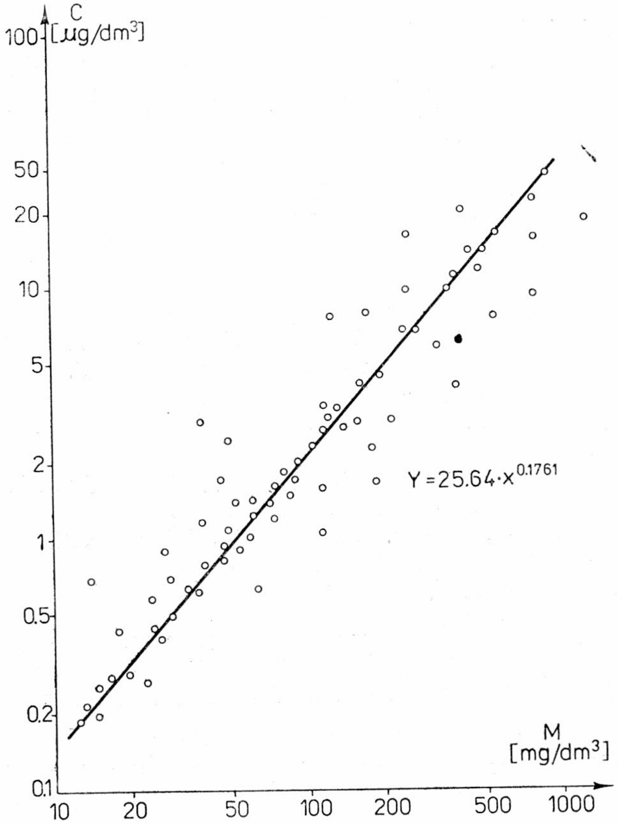

Fig. 9. Beryllium concentration (C) [µg/dm³] in precipitations on recreational grounds vs. mineralization (M) [mg/dm³] of precipitations

Rys. 9. Wpływ mineralizacji (M) [mg/dm³] opadów atmosferycznych na stężenie berylu (C) [µg/dm³] w opadach na terenach rekreacyjnych

4. CONCLUSIONS

1. Beryllium concentration in surface water is directly proportional to its mineralization as well as to the size of the river basin.

2. Mean beryllium concentration in surface water is higher in industrial regions than on recreational grounds.

3. Results concerning the beryllium content in the upper layer of ice provide reliable information about the contribution of power industry to environment pollution.

4. Beryllium enters surface waters with precipitations or by infiltration from soil. The contribution of beryllium migration from soil is 14 times, and from precipitations twice as large in industrial regions as on recreational grounds.

5. Beryllium content in precipitations is conditioned by the quantity of one year's precipitations as well as on their mineralization.

6. An expression is derived describing the relation between the beryllium concentration in surface water and its mineralization and size of the river basin as well as the relation between the beryllium concentration in precipitations and the mineralization and one year's quantity of precipitations.

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NIEKTÓRE PROBLEMY ZANIECZYSZCZENIA WÓD POWIERZCHNIOWYCH BERYLEM

Spośród różnych dróg przedostawania się zanieczyszczeń do wód powierzchniowych oprócz zrzutów ścieków należy wymienić przede wszystkim opady atmosferyczne i infiltrację z gleb, występujących na terenie danej zlewni. Dominacja jednego czy drugiego źródła obciążenia wód powierzchniowych uwarunkowana jest sytuacją lokalną.

Istotna dla poruszanej problematyki była zatem odpowiedź na pytanie: jaki jest udział opadów atmosferycznych i gleby w procesie wzbogacania składu wód powierzchniowych o pierwiastki występujące w środowisku w wyniku emisji zanieczyszczeń stałych. Mamy tu na uwadze te pierwiastki, które w wodzie występują w ilościach większych od ilości gwarantowanych równowagą geochemiczną na obszarze danej zlewni. Zagadnienie to rozwiązano opierając się na analizie zmiany ilorazu C_w/C_0 w funkcji stosunku C_g/C_0.

Zawartość berylu w wodzie — C_w, w opadach atmosferycznych — C_0 oraz w glebie — C_g oznaczono metodą spektrograficzną i metodą absorpcji atomowej z dokładnością do 0,01 ppm.

Przeprowadzone badania wykazały, że udział migracji berylu z gleby jest 14-krotnie, a poprzez opady 2-krotnie większy na terenach przemysłowych w stosunku do górskich.

Na terenach przemysłowych udział opadów atmosferycznych w stosunku do ładunku zawartego w glebie jest rzędu $6 \cdot 10^{-2}$, natomiast na terenach górskich prawie jednakowy. Większy udział w zanieczyszczeniu wód powierzchniowych w porównaniu do opadów atmosferycznych mają obciążone gleby. Stężenie berylu w wodzie powierzchniowej jest wprost proporcjonalne do mineralizacji wody oraz wielkości zlewn rzeki. Średnie stężenie berylu w wodzie powierzchniowej na terenach uprzemysłowionych jest większe od stężenia tego pierwiastka na terenach rekreacyjnych. Zawartość berylu w górnej warstwie pokrywy lodowej jest większa na terenach uprzemysłowionych niż na terenach rekreacyjnych. Ustalono wzór na zmianę stężenia berylu w wodzie powierzchniowej w zależności od jej mineralizacji i wielkości zlewni oraz w opadach atmosferycznych w zależności od ich mineralizacji i sumy opadów atmosferycznych.

AUSGEWÄHLTE PROBLEME DER VERUNREINIGUNG DER GEWÄSSER MIT BERYL

Oberflächengewässer werden sowohl durch Niederschläge wie durch Auslaugungen aus dem Boden verschmutzt. Es handelt sich speziell um solche Elemente, deren Konzentration im Wasser höher sind als das dem geochemischen Gleichgewicht des gegebenen Gebiets entsprechen würde.

Man hatte zu klären, wieviel o.e. Quellen zur Anreicherung der Elementen beitragen. Man bediente sich des Quotienten C_w/C_0 als Funktion von C_g/C_0, wobei entsprechend: C_w — die Berylkonzentration im Wasser, C_0 — im Niederschlag und C_g — im Boden waren. Die Genauigkeit der Bestimmung lag bei 0,01 ppm.

In Industriegebieten stammte 14 mal soviel Beryl aus dem Boden, doppelt soviel kam vom Niederschlag, bei einem Bezugswert gleich eins bei Gebirgsflächen. Auf Industrieflächen war $C_0/C_g = 6 \cdot 10^{-2}$, im Gebirge $C_0/C_g \approx 1$. C_w ist proportional zur Trockensubstanz des Wassers und zur Größe des Einzugsgebiets. Mittlere Berylkonzentrationen sind auf Industriegebieten größer als auf Freizeitgelände; das Gleiche gilt für die obere Schicht der Eisdecke. Für das oben Gesagte sind entsprechende Formeln aufgestellt worden.

НЕКОТОРЫЕ ПРОБЛЕМЫ ЗАГРЯЗНЕНИЯ ПОВЕРХНОСТНЫХ ВОД БЕРИЛЛИЕМ

Среди разных путей попадания загрязнений в поверхностные воды рядом со сбросом стоков следует привести атмосферные осадки и проникновение из почвы на территории данной водосборной площади.

Преобладание того или другого источника загрязнения поверхностных вод обусловлена местными условиями. Существенным для рассматриваемой проблематики стал, таким образом, ответ на вопрос: какую долю составляют атмосферные осадки и почва в процессе обогащения состава поверхностных вод элементами, попадающими в среду в результате эмиссии твердых загрязнений? Имеются в виду те элементы, которые в воде выступают в количестве, превышающем количество, обеспеченное геохимическим равновесием на территории данной водосборной площади. Этот вопрос решен на основе анализа изменения частного C_w/C_0 в функции отношения C_g/C_0. Содержание бериллия в воде (C_w), в атмосерных осадках (C_0) и в почве (C_g) определяли спектрографическим методом и методом атомного поглощения с точностью до 0,01 ppm.

Проведенные исследования показали, что доля миграции бериллия из почвы в 14 раз, а за посредством осадков в 2 раза выше на промышленной территории по сравнению с территорией горной. На первой из них доля атмосферных осадков по отношению к заряду в почве составляет величину порядка $6 \cdot 10^{-2}$; в горной местности она почти одинакова. Более высокая доля в загрязнении поверхностных вод по сравнению с атмосферными осадками приходится на почвы. Концентрация бериллия в поверхностной воде прямо пропорциональна минерализации воды и размеру водосборной площади реки. Средняя концентрация бериллия в поверхностной воде на промышленной территории выше концентрации в местностях для отдыха. Построено выражение, описывающее изменение концентрации бериллия в поверхностной воде в зависимости от ее минерализации и размера водосборной площади, а также в атмосферных осадках в зависимости от их минерализации и суммы атмосферных осадков.