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CONCENTRATION OF ^{226}Ra IN SURFACE WATERS OF KATOWICE AND BIELSKO DISTRICTS

Results from the investigations on the concentration of ^{226}Ra in water on industrial and rural areas have been shown considering the changes in the concentration of this isotope in precipitations, depending on the catchment area and unit run-off.

Systematic investigations of the water activity in a number of rivers have revealed that the level of their pollution is a resultant of many factors, such as the size of catchment area, cumulative properties of the bottom, etc. Higher concentrations of ^{226}Ra in water have been stated on the areas within a direct influence of the power industry. These values are much higher than these characterizing the areas situated beyond this influence.

1. INTRODUCTION

The investigations on the effect of economic activity of man on the level and behaviour of natural radioactive nuclides in the surrounding have confirmed the thesis that radiation background of the environment is continuously increasing. Among the papers so far published there is a number of papers dealing with the effects of industrial activity on the propagation of ^{226}Ra in separate components of the environment, including water and ground ecosystems [2], [6], [11]. Within the Katowice district the concentrations of ^{226}Ra in precipitation ranged from 0.012 to 0.082 pCi/dm^3. The highest concentrations of this element have been recorded in Bytom, Chorzów, Kozłowa Góra, Żary and Strumień. One observes in the last two localities effect a marked of the coal mined in Rybnicki Okręg Węglowy and utilized there by power industry. Despite the fact that the dust fall-out in one month ranged from 12.0 to 13.0 t/km^2 the consecutive precipitations contained 0.082 and 0.055 pCi/dm^3 of ^{226}Ra. In general, it may be stated that in localities characterized by greater amounts of dust fall-out the concentrations of ^{226}Ra is also higher. There is a positive (0.78) correlation between the two parameters [2]. Results obtained by many authors indicate that the concentration of ^{226}Ra in surface waters varies from about 10^{-12} to 10^{-13} g/dm^3, of which 60-70 % remains dissolved

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in form of chlorides or carbonates [6], [7], [10]. Radium is precipitated from water in form of sulphate, its concentration in water depends chiefly on the concentration of ^{230}Th in bottoms. Self-purification of waters from this element takes place in precipitation reaction of calcium carbonate, barium sulphate or ferrum hydroxide [9].

A two year exploitation period uranium ore excavations resulted in formation of a zone of elevated radium concentration. In summer 1969 the concentration of ^{226}Ra in the river Jedlica water amounted to 16.9 pCi/dm^3 [11].

For comparative reasons, the concentration of ^{226}Ra in mineral waters occurring in Brazil amounted to 94.1 pCi/dm^3 [3] and in some surface waters in Switzerland up to 100, pCi/dm^3 [8].

Cumulation of ^{226}Ra by plants in water ecosystem disturbes biochemical processes. Its concentration of about $3 \cdot 10^{-8}$ Ci/dm^3 of water decreases by 1/3 the amount of oxygen produced by the algae *Chlorococus hypnoides*. A drop in nitrogen concentration has been also observed in other species of algae [4].

The presence of dusts from power industry in impurities being under the influence of far-reaching emmision shows that the reception areas situated far away from industrial centres, can be loaded with ^{226}Ra through total fall-out or precipitation. This fact justified our investigations on the concentrations of ^{226}Ra in surface waters of the Katowice and Bielsko districts.

2. METHODS

Investigations were conducted in the years 1974–1976. The concentrations of ^{226}Ra in surface waters and precipitations have been determined according to the method of GOLDIN [1]. This method consists in coprecipitation of radium in form of barium and radium sulphates together with the carriers of barium and lead and in selective separation of barium and radium. Before radiochemical analysis of the samples they were filtrated through ash-free filters. The suspensions remaining on filters were analysed for the control as well as for the presence of radium. 3 radiochemicala analyses have been performed for each samples.

The samples obtained were measured five times during 50 minutes using a set of measuring apparatus. It consisted of scintillation counter SSA-1P and a universal radiometer MSP-3a. Zink sulphide activated with silver was used as the radiation detector. The run of the measuring set was 0.4 imp/min. The set was calibrated with the radium and uranium source of the activity 5000 pCi.

The radium content was calculated from the following formula

$$A = k \cdot \frac{No}{2.22 \cdot W \cdot a \cdot D \cdot V} \tag{1}$$

where

k — coefficient of calibration, pCi/imp$\cdot$min^{-1},

A — activity of ^{226}Ra, pCi/dm^3

No — net number of impulses from the sample, imp/min,

W — chemical yield,

a — coefficient referring to the total activity of the sample with respect to the activity of ^{226}Ra present in sample,

D — coefficient of selfabsorption,

V — volume of sample, dm^3.

3. RESULTS AND DISCUSSION

The dust fall-out and precipitations are the main source of the pollution of the catchment area of the rivers in Katowice and Bielsko districts. The radium content in rainfall and snow varies within a broad range. In general, greater amounts of radium are present in snow. Two year investigations on the radium content did not allow to distinguish any distribution of the radium frequency in precipitations. All the samples taken at different measuring points were characterized by a similar content of radium. It seems if that the observed fluctuations in ^{226}Ra concentrations differentiated the separate localities, then due to a consecutive spreading of ^{226}Ra over the area of hard coal combustion, the localities situated farther would be characterized with the more or less equalized radium background, being proportional to the dustiness of the air. In 1975 and 1976 the precipitations in industrialized localities contained two times greater amounts of radium than the agricultural localities. The radium content in precipitations was proportional to their mineralization. The increase of mineralization from 1000 mg/dm^3 on the areas being under the influence of the industry results in the increase of ^{226}Ra concentration by 7.0 ± 1.2 pCi/dm^3 (fig. 1). These two quantities are correlated biologically, the correlation coefficient amounts

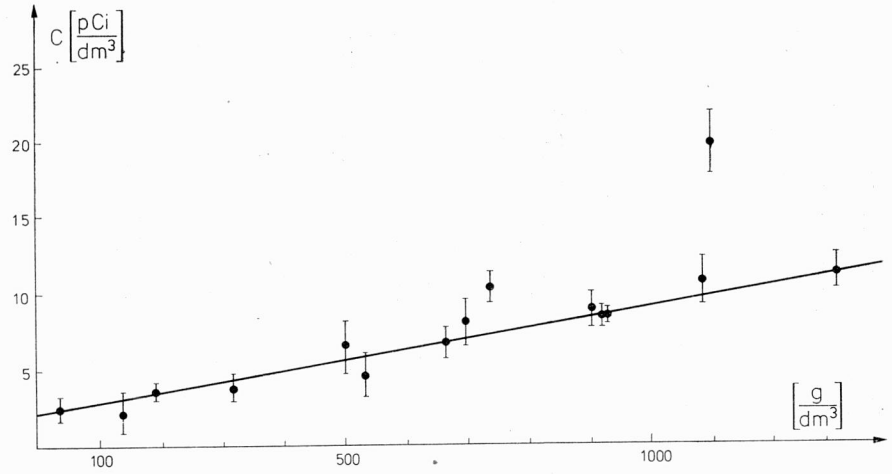

Fig. 1. Content of ^{226} Ra in snow (C) vs. mineralization (M)

Rys. 1. Zawartość ^{226} Ra w śniegu — C w funkcji mineralizacji — M

to $r = 0.78 \pm 0.08$, and the coefficient of significance $t \geqslant 3$. The change in the ^{226}Ra content (y) depending on the mineralization of precipitation (x) is given by the equation

$$y = 0.007x + 2.0.$$

Surface waters receive some amounts of radium through precipitations, soil and ice cover. Ice cover, at a 10 times lower mineralization contains ^{226}Ra in quantities comparable with those in precipitations the mineralization of which is about 1.2 g/dm^3. In one of the limnic reservoirs examined the ice contained 25.5 pCi of ^{226}Ra/dm^3, and 81 mg/dm^3 of chemical compounds, and in reolimnic reservoirs it contained 12.7 of ^{226}Ra pCi/dm^3.

The concentration of ^{226}Ra in water depends to some extent on how many times the water masses are exchanged. In ponds situated near the power plants the water contained many times higher concentrations of radium with respect to the concentrations resulting from hydrochemical equilibrium dependent on radium clerk in geologic environment (medium). In such cases the radium content may reach the value of 5.8 pCi/dm^3. In river water the concentration of ^{226}Ra varied with in 0.2–2.0 pCi/dm^3, except for the parts of rivers loaded with salt water from mines, since then the radium concentration was of the order of 8–11 pCi/dm^3.

While observing the changes in concentrations of ^{226}Ra within a year it has been stated that high values fall to winter and spring. Lower values observed in summer are also due to the cumulation by biota. The effect of the size of catchment area is shown in fig. 2, in which the average contents of ^{226}Ra in some sections of the river examined

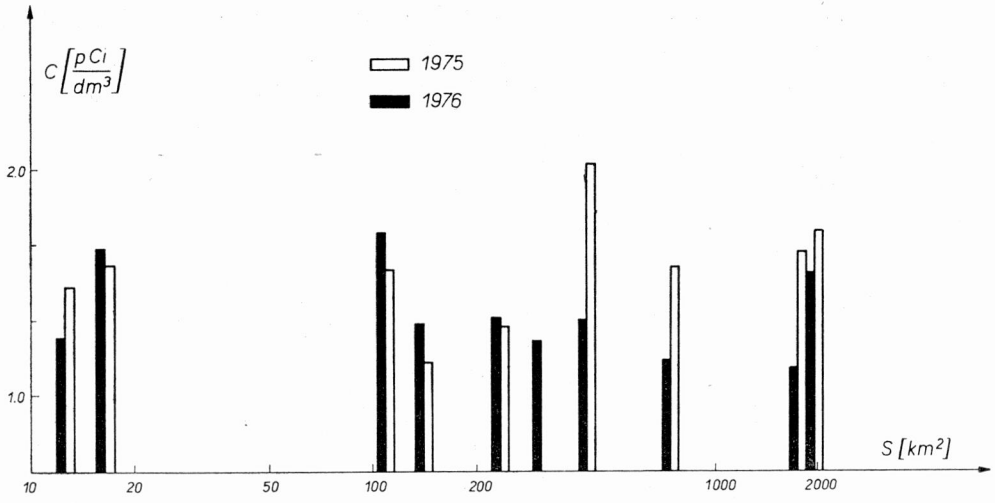

Fig. 2. Concentration of ^{226} Ra in river water (C) vs. the size of catchment area (S)

Rys. 2. Zawartość ^{226} Ra w wodzie rzecznej — C w funkcji powierzchni jej zlewni — S

are shown in form of diagrams. From the observations conducted for two years it follows that there is no close relationship between these quantities.

Fig. 3 presents the change of water activity (expressed in pCi/g) depending on the change in unit run-off (dm s^{-1} km^{-2}). In normal-logarithmic scale the results obtained are arranged in a characteristic way. For high values of run-off the quantity of radium

in dry residue is the greatest. It can be easily understood since the more flowing water falls to the unit of the area the more intensly are washed the elements from the bed, according to characteristic contrast coefficients of their migration in water.

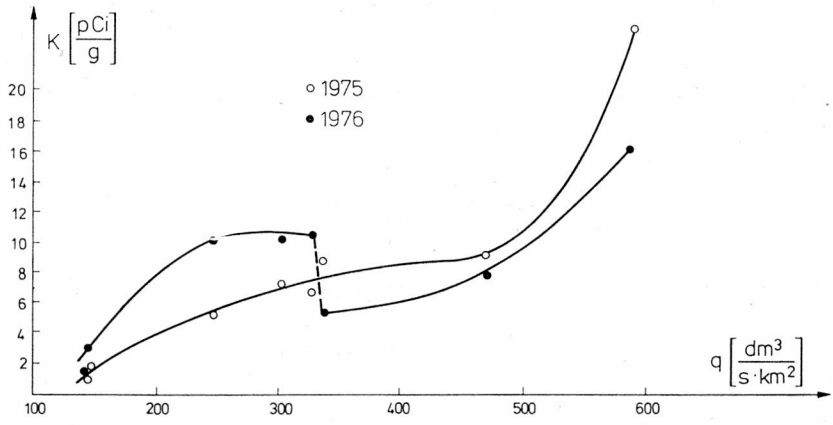

Fig. 3. Loading of ^{226} Ra (K) vs. run-off (q) river water

Rys. 3. Ładunek ^{226} Ra — K w funkcji spływu — q w wodzie rzecznej.

4. CONCLUSIONS

1. The content of ^{226}Ra in precipitations is proportional to their mineralization.

2. Concentration of ^{226}Ra in surface waters from industrial area is higher than in waters from rural areas.

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ZAWARTOŚĆ ^{226} Ra W WODACH POWIERZCHNIOWYCH WOJ. KATOWICKIEGO I BIELSKIEGO

W pracy przedstawiono wyniki badań zawartości ^{226} Ra w wodzie na terenach przemysłowych i rolniczych na tle zmian zawartości tego radioizotopu w opadach atmosferycznych w funkcji zlewni i jednostkowego spływu.

Systematyczne badania aktywności wody wielu rzek wykazały, że poziom ich skażenia jest wypadkową wielu czynników, jak : wielkość zlewni, własności kumulacyjne dna, itp. Wyższe stężenia ^{226} Ra w wodzie obserwowano na terenach pozostających bezpośrednio w zasięgu oddziaływania przemysłu energetycznego. Wartości te są o wiele wyższe od wielkości charakteryzujących tereny leżące poza zasięgiem oddziaływania przemysłu.

^{226} Ra-KONZENTRATIONEN IN OBERFLÄCHENGEWÄSSERN DER BEZIRKE KATOWICE UND BIELSKO

Im Beitrag werden die Ergebnisse von Untersuchungen über ^{226} Ra-Konzentrationen in Gewässern industrieller und landwirtschaftlicher Einzugsgebiete dargestellt. Die erwähnten Konzentrationen wurden mit den Konzentrationen dieses Radioisotopes im atmosphärischen Niederschlag verglichen, wobei das Einzugsgebiet und der spezifische Abfluß die Vergleichsfaktoren bildeten.

Systematische Beobachtungen der Radioaktivität des Wassers verschiedener Flüße haben ergeben, daß der Kontaminierungsgrad als Resultante mehrerer Faktoren anzusehen ist. Zu diesen zählen u.a.: die Flächengröße des Einzugsgebietes, die kumulative Wirkung der Sohle u.ä. Höhere ^{226} Ra-Werte wurden in jenen Gewässern festgestellt, die dem unmittelbaren Einfluß energetischer Betriebe ausgesetzt sind. Dort wo der Einfluß der Industrie nicht hinreicht, sind die Ra-Werte wesentlich kleiner.

СОДЕРЖАНИЕ ^{226}Ra В ПОВЕРХНОСТНЫХ ВОДАХ КАТОВИЦКОГО И БЕЛЬСКОГО ВОЕВОДСТВ

Представлены результаты исследований по содержанию ^{226}Ra в воде в промышленных и сельскохозяйственных районах на фоне изменений в содержании этого радиоизотопа в атмосферных осадках в функции водосборного бассейна удельного стока.

Систематические исследования активности воды многих рек показали, что степень заражения их является результирующей ряда факторов, таких как размер водосборного бассейна, кумулятивные свойства дна и т.п. Более высокая концентрация ^{226}Ra в воде наблюдалась на территории, находящейся в пределах непосредственного воздействия энергопромышленности. Значения её оказываются там гораздо выше по сравнению со значениями, характеризующими районы, расположенные за пределами воздействия промышленности.