Site 2. Former mine settling pond Rontok Wielki

General information

Formal name: Rontok Wielki
Ecosystem: Limnic ecosystem (pond), a flow-through lake currently fed by small local watercourses.

County: Pszczyński
Municipality: Pszczyna

Latitude/Longitude

49˚ 16’ 15.22” N, 19˚ 0’ 15.05” E

Site Location

The Rontok Wielki settling pond is situated on the floodplain of the Vistula River. The pond is located near the village of Rudołtowice about 40 km south of Katowice and about 50 km from the border with the Czech Republic in southern Poland at a height of about 240 m above sea level. Its water is drained into the Vistula river, about 50 m away.

Previous/current use

The area is currently excluded from technological use and the pond is filled with freshwater. Free access to public is permitted. The pond is currently used by a local angler’s association.

Future use

In the future, no changes of the site are to be expected and Rontok Wielki will be left in its current state.

Site description

The area of Rontok Wielki is about 34 ha. It consists of the former salt water reservoir (today filled with freshwater) of about 26 ha and a smaller buffer with freshwater of about 8 ha which was used to protect the surrounding area (especially the area where curative mud is found) from salt waters. Water capacity is 440,000 m^3. The depth of the pond ranges from 0.4 m to 2.0 m, so, it can be classified as polymictic pond where thermocline is not present. The amount of water is about 262,000 m^3. The volume of deposits amounts to 113,000 m^3. The Rontok Wielki reservoir was connected via a pipeline to the Silesia mine. A small stream (about 50 m long), was used to let its water flow into the Vistula river. Today around the ditch no enhanced radioactivity levels can be found.

Fig 1. Localisation of Rontok Wielki

Fig 2. Rontok Wielki water reservoir (August 2014)

History

Rontok Wielki was established in the 16th century for pisciculture. The use of this pond as retention reservoir for mine water before discharge to the Vistula river started in 1977. Since then about 72 million cubic meters of saline waters were pumped into the reservoir from the ``SILESIA" coal mine. The concentration of the suspended load varied from 0.3 to 2.4 g/dcm^3. The total amount of the suspension, deposited in the pond, was calculated as 100 000m^3 (about 150 000 tons). Type A waters (with radium and barium ions) were discharged into the pond during this period. The activity ratio between the two radium isotopes ^{226}Ra: ^{228}Ra was about 2:1. Early discharge was about 10 000 m^3, but since 1998 the discharge of water is much smaller, only 5600 m^3/day. The inflows of sulphate-rich groundwater are small but numerous and therefore precipitation of $BaSO_4$+$RaSO_4$ occurs in the pond. In pond bed deposits, the concentration of radium isotopes is clearly enhanced. After 2003 discharge of mine water was stopped. The saline water was replaced by flooding the pond with fresh water for three times.

Contamination inventory

In 1998 and 1999 the detailed inventory of radioactive contamination done. Radium isotopes, both ^{228}Ra and ^{226}Ra, activity concentration was measured in water and bottom sediments using a 28-points regular sampling grid. Technical parameters of the pond as: bottom sediment thickness, sediment surface altitude and thickness of water layer covering sediments were also recorded.

The spatial distribution of radium in sediment is such that the maximum activity of radium isotopes was found in the southern part of the settling pond, i.e. half-way between the points of inflow and outflow of mine waters to the Vistula River as it can be seen in Figure 3. The maximum radium content in sediments occurred near the outlet of the pipeline that transported water from the mine to the settling pond where the total activity (sum of Ra-226 and Ra-228) amounted to 55 kBq kg^{-1} dry weight. In the northern and western parts of the pond, insignificant inflow of freshwater occurred and radium and barium co-precipitated very slowly, however enhanced concertation of Cs-137 is observed there. In addition, almost no coal remains were found and concentration of radium was less than 500 Bq kg^{-1}. In fact, it resulted that in about 35-40% of the area of the pond the concentrations were below 350 Bq kg^{-1} for Ra-226 and 230 Bq kg^{-1} for Ra-228. In the central part of the reservoir distant from the point of waste inflow, both Ra-226 and Ra-228 isotopes are uniformly distributed. In fact, this is an area where water exchange with the rest of the pond is very little.

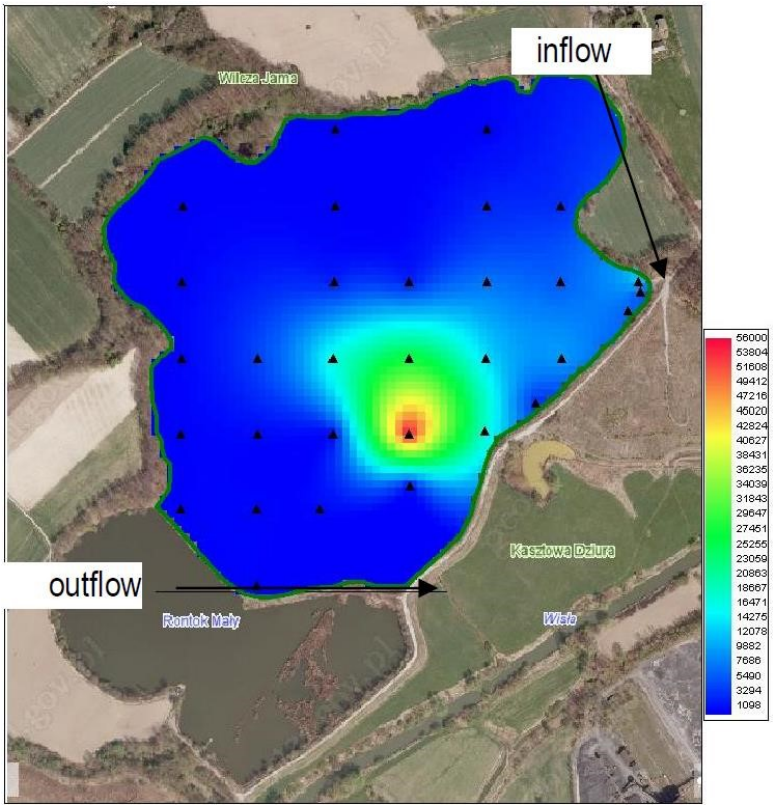

Fig 3. Distribution of radium isotopes (^{226}Ra +^{228}Ra) in sediments, Rontok Wielki water reservoir (1999)

Consistence of sediments of Rontok Wielki is very soft and not compact. The thickness of bottom sediments reaches the maximum value of 1.2 m in the south-east part of the reservoir not far from the mine water discharge from the pipeline. Over an area of about $S=2.5x10^4$ m^2 the thickness of sediment layer exceeds 0.4 m; in the remaining $S=3.3x10^5$ m^2, it ranges from 0.1 m to 0.4 m. The minimum value of this parameter is observed in the northern and western parts of the settling pond. Subsidence caused by underground mining takes place in the northern and eastern parts of the settling pond. The remaining part of the pond is shallow; in this case bottom sediments are below water surface or even near it, i.e. near the waste water outflow to the Vistula river from the pond.

Results are presented in tables 1-3. Distribution of particular parameters measured along the sampling grid is presented in figures 3 - 7

USCB observatory site #2 related open data from GIG resources

Table 1. Activity concentration of radium isotopes in sediments, “Rontok Wielki”

Sampling point No	**Activity concentration** [Bq/kg]				
	^{226}Ra	^{228}Ra	^{224}Ra	^{40}K	^{137}Cs
1/98	198 ±11	89 ± 7	101 ± 7	609 ± 40	60 ± 4
2/98	109 ± 9	101 ± 3	91 ± 9	387 ± 17	33 ± 1
3/98	377 ± 12	140 ± 8	150 ± 15	622 ± 68	33 ± 3
4/98	600 ± 56	170 ± 12	190 ± 17	541 ± 48	430 ± 11
5/98	1037 ± 84	179 ± 24	214 ± 24	364 ± 80	1014 ± 49
6/98	3039 ± 131	1007 ± 490	1133 ± 66	223 ± 54	220 ± 14
7/98	176 ± 5	127 ± 4	126 ± 8	589 ± 46	42 ± 2
8/98	526 ± 18	212 ± 12	208 ± 12	565 ± 56	53 ± 3
9/98	49 151 ± 1473	6292 ± 474	8990 ± 681	550 ± 138	32 ± 12
10/98	14 954 ± 230	2842 ± 115	3390 ± 100	237 ± 42	< 3
11/98	478 ± 20	167 ± 16	188 ± 18	282 ± 70	294 ± 16
12/98	183 ± 9	112 ± 5	117 ± 6	555 ± 54	37 ± 2
13/98	12 720 ± 750	3681 ± 130	4665 ± 186	474 ± 151	94 ± 12
14/98	177 ± 7	109 ± 7	102 ± 10	568 ± 67	28 ± 3
15/98	10 185 ± 155	2920 ± 893	3437 ± 165	438 ± 126	< 3
16/98	5864 ± 108	3700 ± 108	2481 ± 99	548 ± 174	< 3
17/98	178 ± 12	105 ± 6	81 ± 6	155 ± 19	1684 ± 52
18/98	1254 ± 39	667 ± 28	611 ± 28	500 ± 59	95 ± 9
19/98	20 249 ± 586	6388 ± 213	7179 ± 718	525 ± 163	38 ± 5
20/98	5216 ± 174	1823 ± 100	2228 ± 223	600 ± 113	68 ± 18
21/98	4535 ± 155	1110 ± 40	1296 ± 60	534 ± 114	< 3
22/98	6535 ± 100	5130 ± 89	1948 ± 110	666 ± 93	< 3
23/98	81 ± 17	62 ± 10	44 ± 6	304 ± 44	835 ± 25
24/98	1191 ± 29	593 ± 54	597 ± 55	591 ± 110	115 ± 11
25/98	1715 ± 56	675 ± 28	700 ± 28	529 ± 49	54 ± 5
26/98	1931 ± 115	756 ± 20	774 ± 76	848 ± 49	80 ± 6
27/98	67 ± 6	76 ± 4	65 ± 5	482 ± 28	38 ± 3
28/98	219 ± 13	150 ± 9	159 ± 15	529 ± 44	268 ± 20

Table 2. Activity concentration of radium isotopes in water, “Rontok Wielki”

Numer punktu pobrania próbki	**^{226}Ra**	**^{228}Ra**	**Sum of ^{226}Ra and ^{228}Ra**
	[kBq/m^3]		
2	0.377 ± 0.032	0.52 ± 0.11	0.897
3	3.692 ± 0.299	3.34 ± 0.69	7.032
4	3.338 ± 0.270	3.07 ± 0.63	6.408
5	2.775 ± 0.225	2.62 ± 0.54	5.395
6	0.665 ± 0.057	0.62 ± 0.15	1.285
7	2.817 ± 0.229	3.14 ± 0.64	5.957

8	3.517 ± 0.285	3.29 ± 0.67	6.807
9	3.623 ± 0.293	3.12 ± 0.64	6.743
10	3.167 ± 0.257	2.64 ± 0.54	5.807
11	3.609 ± 0.292	3.18 ± 0.65	6.789
12	1.544 ± 0.127	1.49 ± 0.32	3.034
13	3.673 ± 0.297	3.41 ± 0.70	7.083
14	3.307 ± 0.268	3.49 ± 0.71	6.797
15	3.567 ± 0.289	3.40 ± 0.70	6.967
17	3.996 ± 0.323	3.46 ± 0.71	7.456
18	3.741 ± 0.303	3.73 ± 0.76	7.471
19	2.741 ± 0.223	2.57 ± 0.53	5.311
20	3.890 ± 0.315	3.44 ± 0.70	7.330
22	3.698 ± 0.299	3.15 ± 0.65	6.848
24	3.914 ± 0.316	3.47 ± 0.71	7.384
25	3.784 ± 0.306	3.22 ± 0.66	7.004
27	3.822 ± 0.309	3.31 ± 0.68	7.132
28	3.800 ± 0.307	3.74 ± 0.76	7.540

Table 3. Technical parameters describing “Rontok Wielki”

Sampling point No	**Coordinates**		**Bottom sediment thickness** [m]	**Sediment surface altitude** [m above sea level.]	**Thickness of water layer covering sediments** [m]	**Activity concentration ^{228}Ra + ^{226}Ra** [Bq/kg]
	X	*Y*				
1/98	834718	240282	0.10	240.64	0.05	287
2/98	834818	240183	0.17	239.99	0.7	210
3/98	834818	240282	0.30	240.55	0.14	517
4/98	834818	240367	0.12	240.69	0	770
5/98	834849	240485	0.10	240.69	0	1216
6/98	835017	240284	0.14	240.15	0.54	4046
7/98	835017	240185	0.09	240.34	0.35	303
8/98	834917	240383	0.35	240.43	0.26	738
9/98	834917	240483	0.37	240.34	0.35	55 443
10/98	834921	240583	0.37	239.71	0.98	17 796
11/98	834917	240283	0.31	240.46	0.23	645
12/98	834917	240183	0.17	240.21	0.48	295
13/98	835017	240383	0.19	240.18	0.51	16 401
14/98	835218	240385	0.20	238.68	2.01	286
15/98	835017	240584	0.40	239.19	1.5	13 105
16/98	835016	240685	0.45	240.48	0.21	9564
17/98	835117	240185	0.10	240.55	0.14	283
18/98	835117	240384	0.26	240.05	0.64	1921
19/98	835017	240483	0.34	239.73	0.96	26 637
20/98	835117	240585	0.34	238.39	2.3	7039
21/98	835117	240684	0.78	239.67	1.02	5645
22/98	835117	240785	1.20	240.69	0	11 665
23/98	835218	240186	0.05	240.58	0.11	143
24/98	835117	240484	0.30	238.49	2.2	1784
25/98	835218	240585	0.36	237.73	2.96	2390
26/98	835218	240684	0.40	238.73	1.96	2687
27/98	835318	240385	0.12	240.23	0.46	143
28/98	835318	240586	0.21	240.04	0.65	369

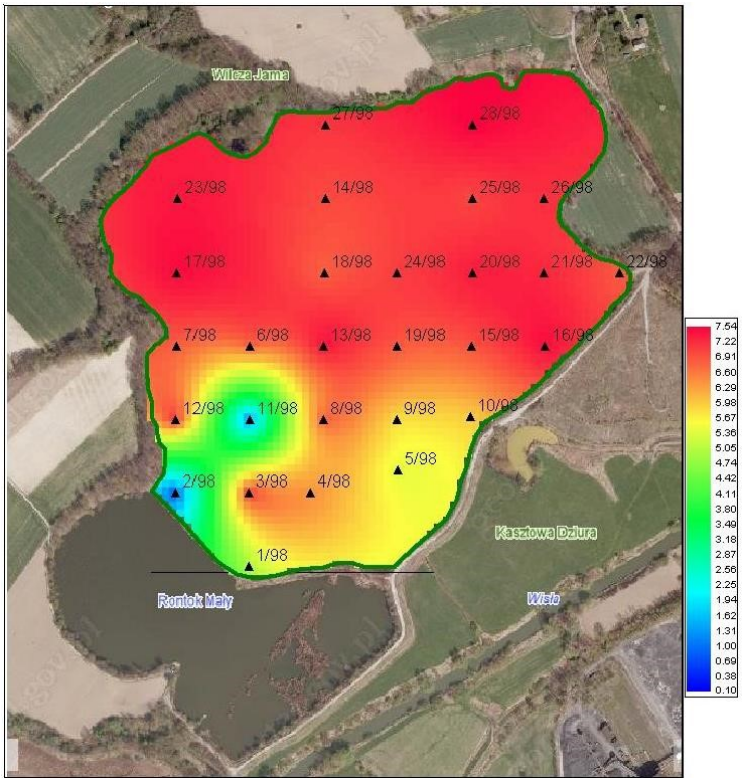

Fig 4. Distribution of radium isotopes (^{226}Ra + ^{228}Ra) in water, Rontok Wielki water reservoir (1999)

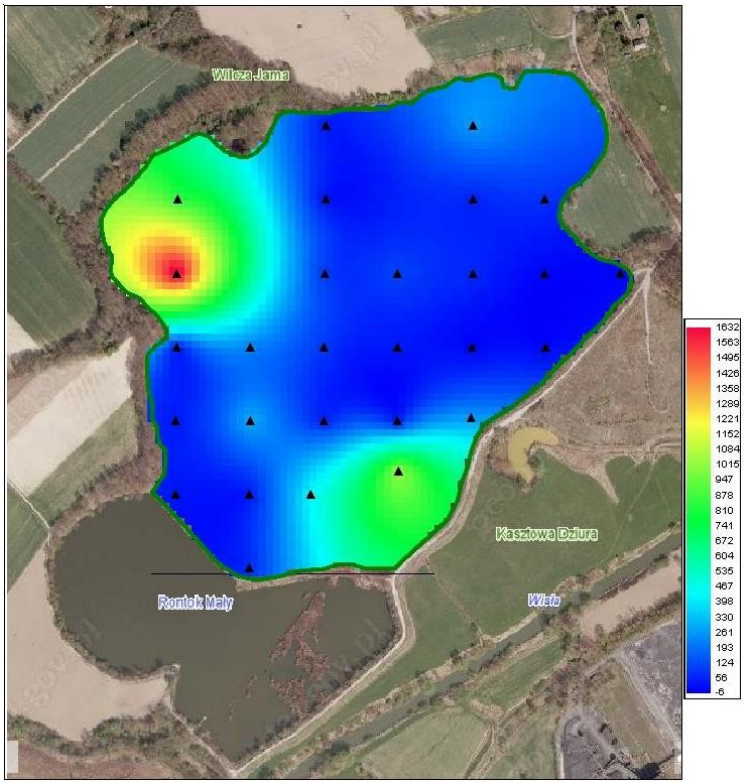

Fig 5. Distribution of ^{137}Cs in sediments, Rontok Wielki water reservoir (1999)

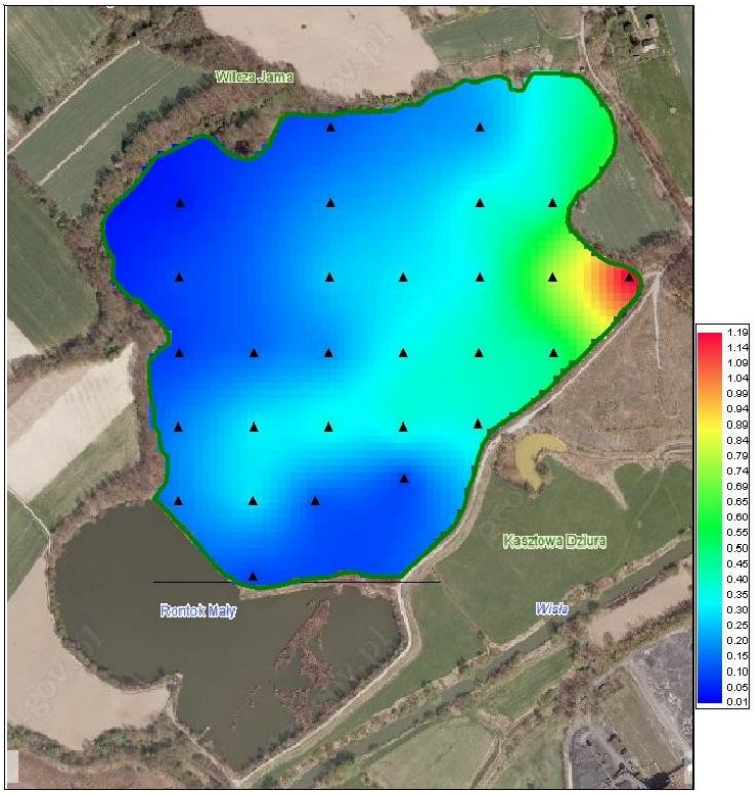

Fig 6. Bottom sediments thicness in Rontok Wielki water reservoir (1999)

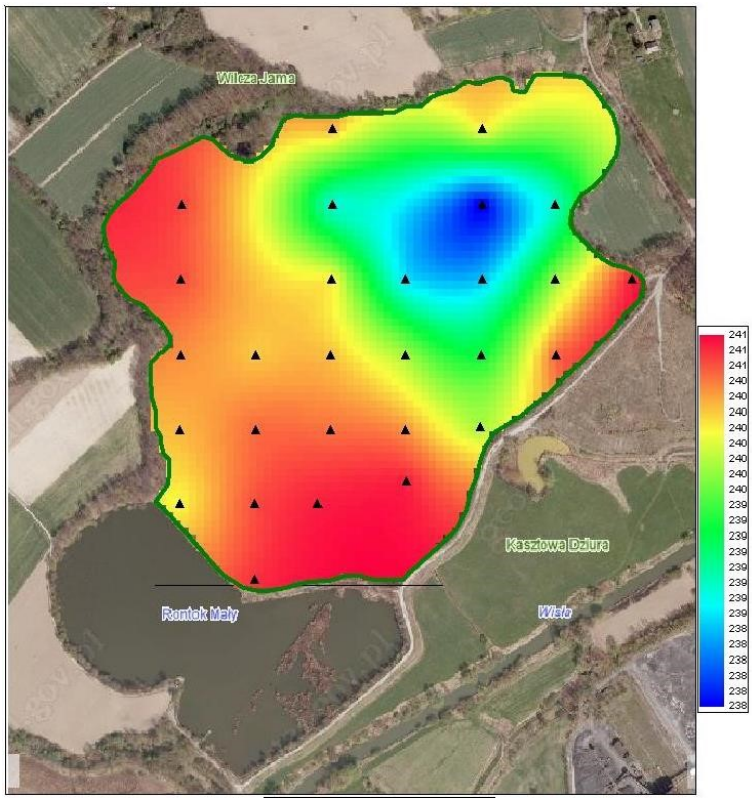

Fig 7. Sediment surface altitude, [m above sea level] (1999)

Water

The pH value in the water of Rontok Wielki (since 2005) met the Polish national standards for purified industrial waste water with a value of pH = 8.20 (national limit 6.5-8.5). In addition, in accordance with a natural water classification in dependence on pH it is weakly alkaline. In accordance to the natural water classification by mineralization Rontok Wielki water can be rated as freshwater. After the pond had been excluded from the mining activity radium content in water was regularly controlled.

The results are present in table 4.

Table 4. Radium activity concentration in „Rontok Wielki", after the mine water discharge was stopped [kBq/m^3]

Sampling date	^{226}Ra	^{228}Ra
April, 2005	0.101 ± 0.009	0.04 ± 0.02
December, 2006	0.272 ± 0.024	0.15 ± 0.04
December, 2007	0.213 ± 0.025	0.03 ± 0.07
December, 2008	0.152 ± 0.012	0.05 ± 0.03
December, 2009	0.106 ± 0.014	0.04 ± 0.06
September, 2010	0.065 ± 0.012	0.02 ± 0.06

Flora

Since salt water have been replaced by the fresh one, Rontok Wielki pond experiences revegetation of the surface and the presence of vigorous biota typical of the area. Natural banks of this pond are overgrown by trees: *Betula pendula*, *Quercus robur*. The most abundant plant is common reed (*Phragmites australis)* transgressing the lake surface.

Fig. 8. Flora around Rontok Wielki

Fauna

The list of birds includes the crested grebe (*Podiceps cristatus*), mute swan (*Cygnus olor*), Caspian tern (*Hydroprogne caspia*) and grey heron (*Ardea cinerea*). The mallard (*Anas platyrhynchos*) falls within the definition of the ICRP reference duck.

Also, in year 2000, presence of birds familiar for the seashores more than for the inland pond was observed. These were shanks (*Tringa),* sandpipers *(Actitis),* gulls *(Larus),* stints *Calidris,* plovers *(Charadrius).* This is most probably due to mixing waters lead to an increase of water temperature and at that time the area resembled environmental seashores.

The list of fish species includes predators common for lowing and stagnant freshwater: catfish (*Silurus glanis*), pike-perch (*Sander lucioperca*), perch (*Perca fluviatilis*) and pike (*Esox lucius*). The predominant herbivorous fish species are common roach (*Rutilus rutilus*), crucian carp (*carassius carassius*), carp bream (*Abramis brama*), tench (*Tinca tinca*), common carp (*Cyprinus carpio*) and grass carp (*Ctenopharyngodon idella*). Some amphibians are assumed to be present on the banks of the settling pond. Earthworms and round worms (phylum Nematoda) are expected to occur in bank sediments.

Fig. 9. Fauna around Rontok Wielki

Long term behaviour of Radium

Selected as long-term observatory site Rontok lake water reservoir allowed identification of processes leading to accumulation of radium in bottom sediments and observation of its further behaviour from 17-years-time perspective. New data were collected during two-years monitoring campaign and compared with archive data on radioactivity in water and sediments collected in 1999. Radium-barium co-precipitation process was identified as main source of sediments heavy contamination, however, radium chemical form resulted from this process is insoluble and not easy migrate to other environmental compartments, what was proved by low ^{226}Ra and ^{210}Pb transfer to water measured under laboratory condition and to biota observed on site. As barium is not always present in mine radium rich brines a discussion is launched what would happen when such waters are released into environment based on simple laboratory experiment.

The main conclusion is underlined that the current radium activity concentration in sediments (2016) is lower than expected only considering radioactive decay. Distribution of ^{226}Ra, ^{228}Ra and ^{210}Pb in sediment profiles suggest that bio- or mechanical turbation (e.g. local flood) is responsible for significant ^{226}Ra deficiency observed. For more information see:

Michalik B. Wysocka M., Bonczyk M., Samolej K., Chmielewska I. Long term behaviour of radium rich deposits in a lake ecosystem. (In press). J. Envion. Radioact.

Zebracki M., Bonczyk M., Chmielewska I., Diez O., Wysocka M., Cazala C., Importance of redox interface regarding the fate and behaviour of radium in surface water impacted by NORM, Proceedings of the IAEA NORM-IX Symposium, Denver (US), September 23-27, 2019 (in press).

Due to economic situation and enforced limits in coal use rapid changes in coal mining industry in Poland are going on. Radioactivity is not considered to be important especially in the light of nor precise regulation in this field. In 2017 Rontok lake was sold to a private company and transferred into a repository of mine waste rock. A significant part of the lake is currently filled with waste rock and the process is going on.. see pictures below.

Use of the site as an observatory is irretrievable…on the other hand, thick layer of mine waste rock with content of natural radionuclides at the level not significantly exceeding natural background may be considered as a land reclamation, to some extent.

Fig. 2 Rontok lake partially filled with mine waste rock.