

MULTIVARIATE STATISTICAL ANALYSES ON ARSENIC OCCURRENCE IN RYBNIK RESERVOIR

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Abstract: Popular statistical techniques, such as Spearman's rank correlation matrix, principal component analysis (PCA) and multiple linear regression analysis were applied to analyze a large set of water quality data of the Rybnik Reservoir generated during semiannual monitoring. Water samples collected at 9 sampling sites located along the main axis of the reservoir were tested for 14 selected parameters: concentrations of co-occurring elements, ions and physicochemical parameters. The aim of this study was to estimate the impact of those parameters on inorganic arsenic occurrence in Rybnik Reservoir water by means of multivariate statistical methods. The spatial distribution of arsenic in Rybnik Power Station reservoir was also included. Inorganic arsenic As(III), As(V) concentrations were determined by hydride generation method (HG-AAS) using SpectrAA 880 spectrophotometer (Varian) coupled with a VGA-77 system for hydride generation and ECT-60 electrothermal furnace. Spearman's rank correlation matrix was used in order to find existing correlations between total inorganic arsenic (As^{tot}) and other parameters. The results of this analysis suggest that As was positively correlated with PO_4^{3-} , Fe and TDS. PCA confirmed these observations. Principal component analysis resulted in three PC's explaining 57% of the total variance. Loading values for each component indicate that the processes responsible for As release and distribution in Rybnik Reservoir water were: leaching from bottom sediments together with other elements like Cu, Cd, Cr, Pb, Zn, Ni, Ca (PC1) and co-precipitation with PO_4^{3-} , Fe and Mn (PC3) regulated by physicochemical properties like T and pH (PC2). Finally, multiple linear regression model has been developed. This model incorporates only 8 (T, pH, PO_4^{3-} , Fe, Mn, Cr, Cu, TDS) out of initial 14 variables, as the independent predictors of total As contamination level. This study illustrates the usefulness of multivariate statistical techniques for analysis and interpretation of complex environmental data sets.

INTRODUCTION

Arsenic is a highly toxic semi-metal and a documented human carcinogen, widely spread in the environment. Estimation of arsenic contamination is important for many reasons, mainly because of its harmfulness for human health. Contaminated potable water is the most important source of arsenic exposure [35]. The acceptable level as defined by the Regulation of the Minister of Health for maximum concentration of arsenic in safe potable water is $10 \mu\text{g}\cdot\text{L}^{-1}$ [27]. The natural concentration of arsenic in

surface waters can fluctuate between tens $\mu\text{g}\cdot\text{L}^{-1}$ parts and tens $\mu\text{g}\cdot\text{mL}^{-1}$ parts, usually below $10\ \mu\text{g}\cdot\text{L}^{-1}$ [6, 16, 31].

Mining, smelting, burning fossil fuels and fertilizers production are the major industrial processes that contribute to anthropogenic arsenic contamination [13]. The Upper Silesian District is a region with enormous concentration of industry, mainly hard coal mining and electric power industry, hence a strong attention is directed to research of Upper Silesian area surface water contamination by arsenic presence.

In the environment arsenic exists in several oxidation states (-3, 0, +3, +5) in inorganic or organic forms. Arsenic in surface-water systems exists primarily as either oxidized pentavalent arsenate or reduced trivalent arsenite oxyanions [32]. Arsenate (V) is most often found as H_3AsO_4 whereas arsenite (III) is mostly present as H_3AsO_3 [5]. Toxicity of arsenic depends on its chemical form, resulting in increasing interests in the quantitative determination of individual species. Inorganic arsenic forms are generally much more toxic than organic ones, although trivalent forms are known to be the most toxic [5]. The chemical forms and oxidation states of arsenic in water environment are subject to a great number of different processes, of which the most important are co-precipitation and sorption [11]. The presence of Fe/Mn/Al oxihydroxides, sulfide minerals, phosphate and organic carbon together with alkaline conditions favor the release of arsenic from bottom sediments into water [5, 32]. The factors mostly affecting the speed and direction of these processes are pH and redox potential. Acid-base reactions control the speciation of arsenic between different chemical forms and the equilibrium distribution of the As between the oxidation states is controlled by redox potential [3, 7]. Arsenic spatial distribution between surface and bottom water layer is dynamic, although its concentration in bottom layer is generally higher [19, 20]. Since toxicity and mobility varies with the speciation of arsenic, it is essential to identify mechanisms responsible for As occurrence in water in a species-specific manner.

In surface water arsenic release and proportions of arsenic species depend on many interrelated factors and this fact causes difficulties in data interpretation. In such cases, some form of multivariate statistical analysis might be appropriate [25, 29]. The principal goals of this study was to quantify the occurrence and distribution of arsenic species (As(III) and As(V)) in the Rybnik Reservoir water by means of multivariate statistical methods. Spearman's correlation matrix, principal component analysis and multiple regression analysis were applied to examine arsenic association with other elements, ions and physicochemical water parameters.

MATERIALS AND METHODS

Field investigations were carried out between February and July 2010 in Rybnik Reservoir, (Silesian District, Poland). Water samples ($n = 204$) were collected at 9 sampling sites located along the main axis of the reservoir (Fig. 1). Water samples were taken from the surface and near-bottom layers and from various depths (depending on location), by water sampler "Toń-2". Positions 1; 2; 3; 4 were located in the shallow zone (max depth 2 m) close to the backwater, positions 5; 6 in the center zone (max depth 8 m) and positions 7; 8; 9 in the dam zone (max depth 10 m). Water samples of $2\ \text{dm}^3$ volume each were filtered by use of cellulose-nitrate membrane filters ($0.45\ \mu\text{m}$). Samples were preserved by the addition of 1.0 M nitric acid through, leading to pH below 2, and stored in the

dark at room temperature until analysis to avoid chemical or biological changes. The physicochemical parameters were determined by standard methods. The concentrations of major ions (NO_3^- and PO_4^{3-}) were determined using an ion chromatography system DX-120 (DIONEX).

Arsenic was determined by atomic absorption spectrometry hydrides generation method (HG-AAS) with a Varian SpectraAA 880 spectrometer (Varian, Australia) equipped with Vapor Generation Accessory VGA-77 and Electrothermal Temperature Controller ETC-60. Arsenic (III) standard stock solution was prepared by dissolving As_2O_3 (Merck) in 1.0 mol/L^{-1} NaOH, with 0.5 mol/L^{-1} HCl addition [23]. Arsenic (V) standard stock solution was prepared from H_3AsO_4 in 0.5 mol/L^{-1} HNO_3 (Merck). Calibration standards of lower concentrations were prepared by diluting corresponding stock standards (1 g/L^{-1}) by high purity deionize water (Millipore) and HNO_3 (Merck Suprapur) addition. The VGA-77 acid channel was filled with 10 M HCl and the reduction channel with 0.5% (w/v) NaBH_4 in 0.5% (w/v) NaOH. To each sample KI was added to get 1% (w/v) concentration in the solution; the reaction time was 30 min at room temperature. The cycle of operations needed for determination of arsenic concentration at a certain degree of oxidation As(III), As(V) was as follows:

- determination of the total concentration of As (III+V) subjected to preliminary reduction by KI,
- estimation of As(III) – complete volatilization of arsenate in the absence of pre-reducing step achieved by using NaBH_4 [2, 4].

Method's validation was carried out with the support of standard reference material CRM-TMDW (High – Purity Standards). Statistical analysis was performed using Statistica 9.1 PL Software (StatSoft).

STUDY AREA

Rybnik Reservoir is a dam reservoir built in the 1970s for the Rybnik Power Plant purposes. The reservoir is intended for cooling condensers of the Rybnik coal-fired power station and replenishing the closed cycle of the station with water. The use and discharge of cooling water into reservoir results in heat emission, which increases water temperature and stimulates eutrophication. The reservoir is fed mainly with waters of the Ruda River. Its left tributary – the Nacyna River, because of its high pollution is repumped and led into the Ruda River below the main dam. The location of the reservoir within the range of local emission from the Upper Silesian District area led to the assumption that Rybnik Reservoir might be polluted by arsenic.

RESULTS AND DISCUSSION

Arsenic distribution and other chemical parameters of water

Descriptive statistics of output data is presented in Table 1. Total concentration of arsenic in the Rybnik reservoir water ranged from 0.68 to $3.35 \mu\text{g}\cdot\text{L}^{-1}$. Similar concentrations were found in municipal water in 13 cities of the Upper Silesian Industrial Region [14]. As(V) concentration (0.97 ± 0.33) $\mu\text{g}\cdot\text{L}^{-1}$ dominated over As(III) concentration (0.37 ± 0.13) $\mu\text{g}\cdot\text{L}^{-1}$. Marked As(V) prevalence in water reservoirs under oxidizing conditions was highlighted by many authors [21, 22, 33].

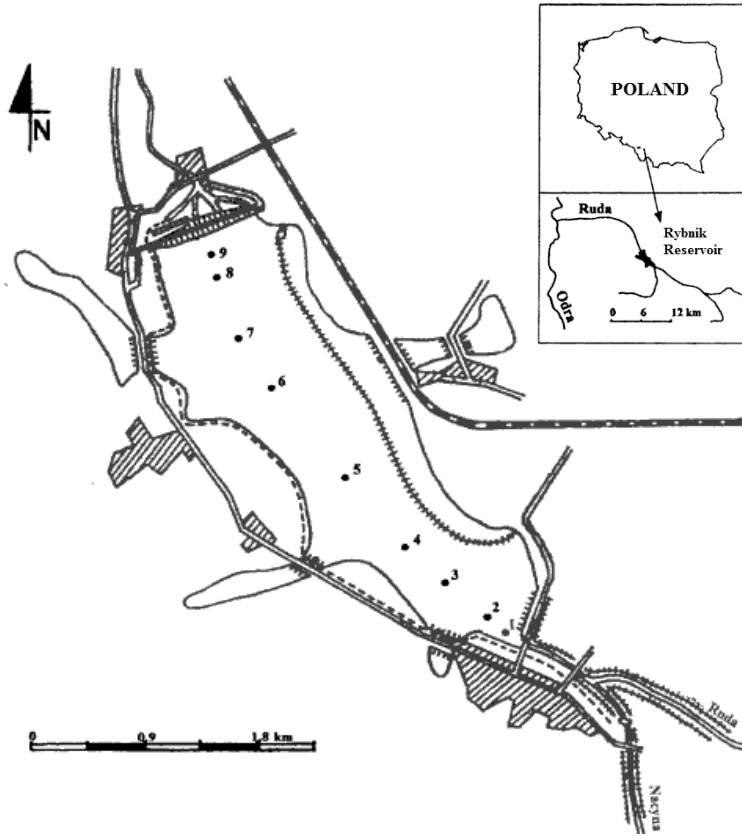


Fig. 1. Location of sampling sites in the Rybnik Reservoir area

The As concentrations at all the sampling sites reached the highest levels in deeper layers, on average $1.29 \mu\text{g}\cdot\text{L}^{-1}$ in the surface water up to $1.57 \mu\text{g}\cdot\text{L}^{-1}$ in the near-bottom layer. As(III) and As(V) vertical distributions for surface and near-bottom water layer were found to be $0.36\text{--}0.42 \mu\text{g}\cdot\text{L}^{-1}$ and $0.93\text{--}1.14 \mu\text{g}\cdot\text{L}^{-1}$ respectively. Significant ($p < 0.05$) differences in arsenic concentrations between those two layers were confirmed by Kruskal-Wallis one-way ANOVA variance analysis and Mann Whitney U test – As(III) KW-H $p = 0.0401$; As(V) KW-H $p = 0.0177$ (Fig. 2).

Vertical profile of arsenic followed the distribution patterns observed in other water reservoirs [17]. The concentrations of particular arsenic forms As(III), As(V) at nine examined sampling sites were generally similar. No significant differences were found concerning arsenic horizontal distribution (Kruskal-Wallis one-way ANOVA test and Mann Whitney U test, $p > 0.05$). Total arsenic concentration at individual sites followed in ascending order: shallow zone > dam zone > center zone. Therefore, no connection between the Ruda inflow and arsenic pollution profile could be found.

To explain the relationship between Rybnik Reservoir water chemistry and As distribution several hydrogeochemical processes have to be discussed. There is much

Table 1. Physicochemical parameters and concentrations of selected elements and ions in the water of Rybnik Reservoir, n = 204

	T [°C]	pH	As(III) µg·L ⁻¹	As(V) µg·L ⁻¹	TDS µg·L ⁻¹	NO ₃ ⁻ µg·L ⁻¹	PO ₄ ³⁻ µg·L ⁻¹	Cd µg·L ⁻¹	Cr µg·L ⁻¹	Cu µg·L ⁻¹	Fe µg·L ⁻¹	Mn µg·L ⁻¹	Ni µg·L ⁻¹	Pb µg·L ⁻¹	Zn µg·L ⁻¹	Ca µg·L ⁻¹
Mean	19,5	8,03	0,37	0,97	472,33	1,1	0,23	0,91	2,34	20,11	135,52	76,88	8,82	6,34	36,65	59,06
Median	19,3	7,80	0,35	0,91	459,00	0,99	0,22	0,94	2,00	19,45	117,30	38,85	8,80	5,30	31,15	56,75
Standard Deviation	6,6	0,64	0,13	0,33	65,81	0,60	0,10	0,58	1,35	11,08	106,10	111,24	2,57	3,48	18,05	9,42
Minimum	8,0	7,11	0,19	0,49	291,00	0,19	0,04	0,00	0,40	3,90	17,80	7,30	2,50	1,40	16,70	2,00
Maximum	31,0	9,87	0,93	2,42	641,00	2,38	0,63	2,61	7,60	126,00	690,60	807,60	18,90	18,20	146,70	87,70

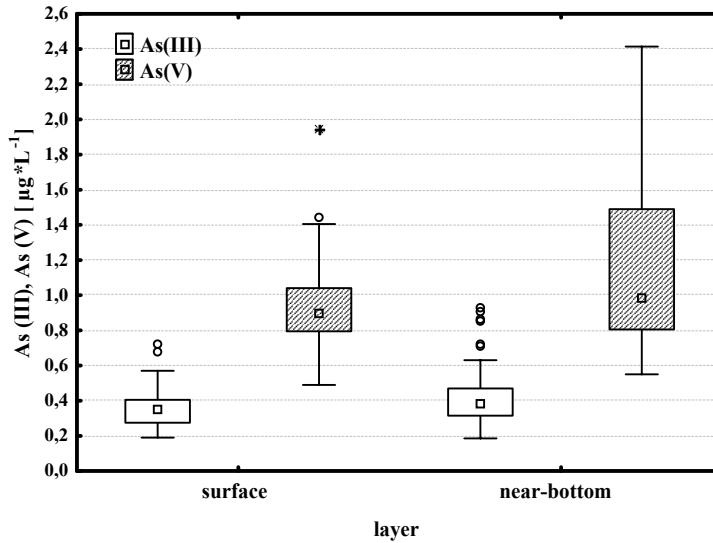


Fig. 2. As(III) and As(V) spatial distribution between surface and near-bottom layer in the water of Rybnik Reservoir

of evidence for arsenic spatial distribution connected with pH and redox potential [5, 32]. Water pH was predominantly alkaline and ranged from 9.8 in surface layer to 7.7 in near-bottom layer. In alkaline waters cationic trace elements are readily adsorbed onto particle surfaces such as iron and manganese oxides/hydroxides, whereas they are resolubilized from solid phases when pH decreases. In contrast, arsenic as an anionic trace element tends to desorb from particulate phases such as Mn/Fe oxyhydroxides in alkaline conditions [15]. These reports are consistent with the obtained results. A strong link occurs between As, Mn and Fe compounds distribution versus water depth, confirming that iron and manganese release from bottom sediments probably favored arsenic dissolution. Scatterplot for sampling position 7 (Fig. 3A) presents As(III), As(V), Fe and Mn distribution between particular water depths, although the same linear trend was observed at all sampling sites [20]. Recent studies on stratified reservoirs have shown that As(V) usually predominates in the oxidized upper layers, whilst As(III) may persist in the anoxic bottom layers when reducing agents, such as Fe and Mn are present [9, 18]. As(V) chemical form predominated regardless water depth (Fig 3A). As(V)/As(III) ratio at 0 m depth was 2.67, while at 10 m depth it was higher and amounted to 3.14 and directly correlated with Mn and Fe concentrations throughout vertical profile.

Several studies on arsenic occurrence in surface water have reported seasonal variations in arsenic concentration [12, 28]. Rybnik Reservoir is contaminated thermally to a large extent, the average annual temperature is approximately 18°C. The temperature of water affects substantially a number of processes occurring in the reservoir, among others oxygen depletion with water depth and biological processes intensification. Arsenic concentration in Rybnik Reservoir was around 30% higher during spring months than in winter, and might have been associated with a rise in total dissolved solids and phosphate

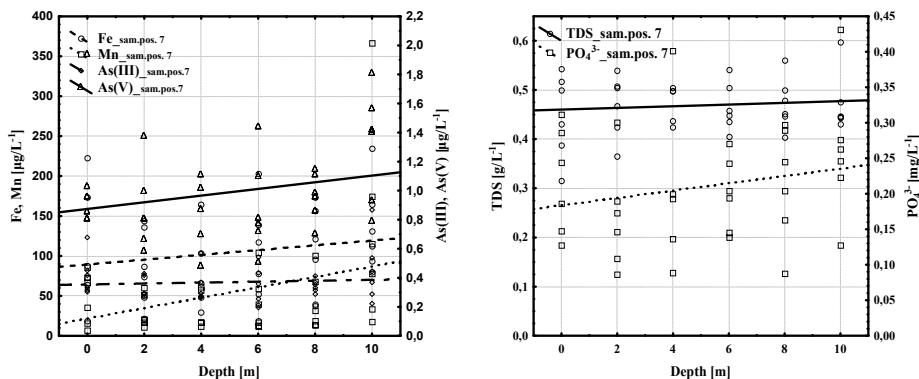


Fig. 3. As(III), As(V), Fe, Mndistribution versus water depth (A); TDS, PO_4^{3-} distribution versus water depth (B)

concentrations due to eutrophication. A rise in arsenic concentration with water depth was correlated with a rise in TDS and PO_4^{3-} concentrations (Fig. 3B). Shapiro *et al.* [30] reported that arsenic release may be caused by arsenic co-precipitation with phosphate. It is also documented that microorganisms use arsenic instead of phosphorus, since As(V) behaves similar to pentavalent phosphorus (PO_4^{3-}) [24]. An alternative explanation for increased arsenic concentrations in the near-bottom water layer may be arsenic adsorption on particulate matter [8]. Total Dissolved Solids (TDS) is considered as primary pollutant in Rybnik Reservoir and exceeds the permissible level for clean surface water [26]. TDS might be responsible for accelerating As mobilization from sediments since dissolved compounds, such as organic matter and inorganic colloids, have been proven to enhance arsenic mobility [12].

Multivariate analysis

Before the analysis the raw data were standardized through z-scale transformation to avoid misclassifications arising from different orders of magnitude of analyzed parameters and their variance. In order to test the goodness-of-fit of the water data to log-normal distribution the Kolmogorov–Smirnov statistic was used. The results obtained by K-S test showed that data distributions were generally non-normal in all analyzed groups at 95% confidence level. To investigate the correlation structure between 14 measured parameters and to find positive or adverse influences between them, Spearman's non-parametric correlation coefficients were used. To confirm interrelationships between variables found in Spearman's rank coefficient matrix and to enable reduction of their number, PCA analysis was performed. Finally, multiple linear regression analysis was applied to estimate the arsenic contamination level by measuring water parameters, as independent predictors of arsenic contamination.

Spearman's rank correlation matrix

To illustrate the correlation coefficients between variables Spearman's rank correlation matrix was used. It presents the monotonic relationship between two variables by indicating either positive or negative magnitude. Table 2 presents statistical relationships among the observed As concentration and other water parameters. The values of these

Table 2. The co-occurrence of elements and ions in Rybnik Reservoir water (n = 204, bold-significant correlations, p < 0.05)

	As ^{tot}	T	pH	TDS	NO ₃ ⁻	PO ₄ ³⁻	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn	Ca
As ^{tot}	1,00														
T	0,09	1,00													
pH	0,03	0,78	1,00												
TDS	0,16	0,39	0,43	1,00											
NO ₃ ⁻	0,08	-0,26	-0,22	0,03	1,00										
PO ₄ ³⁻	0,32	-0,37	-0,47	-0,01	-0,00	1,00									
Cd	0,08	0,38	0,23	0,03	-0,59	0,05	1,00								
Cr	-0,02	0,30	0,17	-0,10	-0,50	-0,18	0,38	1,00							
Cu	0,01	-0,13	-0,19	-0,12	-0,34	0,24	0,27	0,17	1,00						
Fe	0,15	0,51	0,26	0,02	-0,39	0,09	0,58	0,45	0,10	1,00					
Mn	0,01	0,01	-0,12	-0,22	-0,01	0,07	0,20	0,16	-0,01	0,63	1,00				
Ni	-0,13	-0,53	-0,36	-0,40	0,10	0,05	-0,24	0,01	0,02	-0,30	-0,03	1,00			
Pb	-0,15	0,47	0,35	-0,01	-0,32	-0,29	0,35	0,43	-0,09	0,50	0,29	-0,17	1,00		
Zn	0,01	0,71	0,46	0,13	-0,50	-0,19	0,56	0,59	0,10	0,70	0,28	-0,36	0,54	1,00	
Ca	-0,11	-0,46	-0,34	-0,22	-0,22	0,33	0,15	-0,09	0,48	-0,15	-0,09	0,19	-0,26	-0,24	1,00

coefficients varied depending on water depth and sampling localization, showing once again that spatial distribution strongly influences arsenic concentration. For example, the correlation between As and PO_4^{3-} in the center zone (max depth 8 m) was 0.56 while in the dam zone it was 0.33 (max depth 10 m). Regardless sampling depth and localization arsenic showed statistically significant correlation with, TDS, Fe and Pb confirming primary spatial distribution observations.

Co-precipitation and sorption on particulate matter are major processes that contribute to arsenic mobility [5, 32]. The correlation coefficient between As – TDS (0.16) confirmed the fact that total dissolved solids participate in As mobilization. Correlations found among As – Fe (0.15) and As – PO_4^{3-} (0.32), As – TDS (0.16) might reflect their probable co-existence and co-precipitation characteristics (Table 2). A significant correlation between arsenic and PO_4^{3-} supports hypothesis that enhanced microbial activity accelerated by high eutrophication and oxygen depletion could affect As mobilization from sediments. It is also known that inorganic As(V) and phosphate have very similar hydrolysis behavior [10, 24]. Smith *et al.* [33] documented increased As release with water depth in Stuarts Point groundwater system (Australia) caused by pH-influenced desorption from iron oxyhydroxides and by leaching from the clay material. The results obtained are all consistent with data presented by Rahman *et al.* [25]. They found that As may have substantial positive correlations with Fe, Mn, Al, DOC and PO_4^{3-} . Significant correlations between Fe – Mn (0.63), Fe – Zn (0.7), Fe – Pb (0.5), Fe – Ni (-0.3) may indicate that Fe plays an important role in mobility of not only arsenic but also of other elements.

Principle component analysis

The PCA analysis was applied in order to find general regularity and similarities between measured parameters. Three principal components PC1, PC2, PC3 extracted using the Kaiser criterion, explained approx. 57% of the variation in the original data set. The variance indicates the amount of total information presented by each factor. The variance explanation of the PCs was 28.3% for PC1, 16.96% for PC2, 11.36% for PC3. Cu, Cd, Cr, Pb, Zn, Ni, Ca variables had high positive loadings on PC1; T, pH, TDS variables had high participations on PC2 and As together with Fe, Mn, PO_4^{3-} showed high values on PC3. NO_3^- had an insignificant relationship with As, since this was placed dispersedly in the plot. The relationship of As with other parameters such as Fe, Mn, and PO_4^{3-} revealed in distribution analysis, can be visualized in the frames on the loading plot after Varimax rotation (Figure 4). Iron and manganese seem to be linked with As (PC3) and partially may be responsible for As release. The presented results confirm the popular hypothesis of release of arsenic from the surface of hydrated oxides of Fe / Mn as the main mechanism for its mobilization which might be accelerated by the dominance of competitive ions such as those of phosphate. These findings are very much consistent with multivariate analysis presented in works by other authors [1, 29].

Multiple regression analysis

In order to determine which water parameters were most highly related to arsenic concentration, a multiple regression analysis was performed. Generally a multiple regression analysis attempts to fit the independent variables for predicting a single dependent variable. The general form of a multiple regression model is as follows [34]:

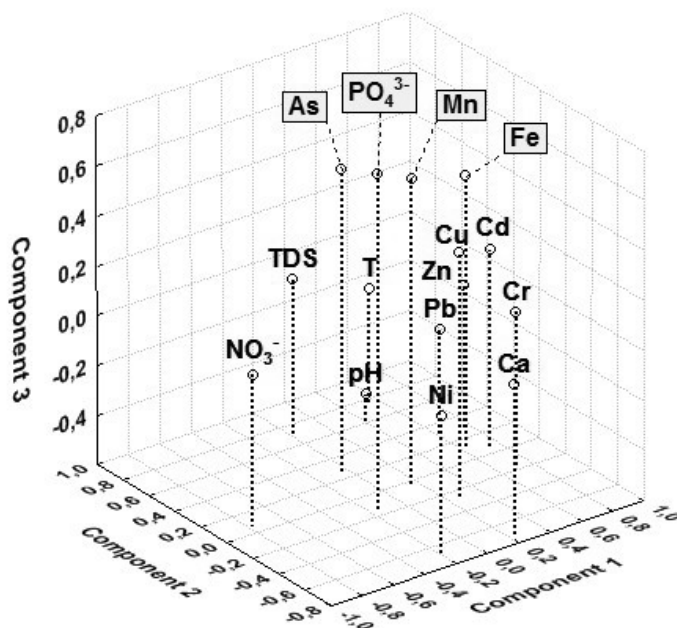


Fig. 4. The principal component analysis of selected water parameters from Rybnik Reservoir

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \xi \quad (1)$$

Where:

$X_1, X_2, X_3, \dots, X_n$ – independent variables,

Y – dependent variable,

$\beta_0, \beta_1, \beta_2, \beta_3$ – correlation coefficients,

ξ – randomized factor.

Based on the relationships between arsenic and other participating parameters found in the correlation matrix and PCA analysis, a multiple regression model was developed. Backward elimination involved all variables and testing them one by one for statistical significance. The analysis of variance showed that only 8 of 14 initial predictor variables have a statistically significant influence on arsenic contamination.

Values presented in Table 3 show that T, pH, TDS, PO_4^{3-} , Cr, Cu, Fe, and Mn play an important role in the mobility of arsenic and strongly supports the observations found in the Sperman's correlation matrix. Based on b-values listed in Table 3 a final regression model can be formulated as:

$$As^{Tot} = 0.51 \cdot T - 0.45 \cdot pH + 0.32 \cdot PO_4^{3-} - 0.23 \cdot Fe + 0.20 \cdot TDS + 0.19 \cdot Mn + 0.18 \cdot Cr - 0.14 \cdot Cu \quad (2)$$

Such a model could be useful for example in the As contamination prediction in similar water reservoirs or in designing a system for As removal from polluted water.

Table 3. Parameter estimation (bold – significant influences, p-value < 0.05)

N=204	b*	Std.error.for b*	b	Std. error. for b	t-value	p-value
T	0.512	0.098	0.512	0.098	5.205	0.000
pH	-0.453	0.102	-0.453	0.102	-4.440	0.000
TDS	0.207	0.077	0.207	0.077	2.682	0.008
PO₄³⁻	0.321	0.072	0.321	0.072	4.443	0.000
Cr	0.184	0.068	0.184	0.068	2.696	0.008
Cu	-0.146	0.063	-0.146	0.063	-2.340	0.020
Fe	-0.233	0.096	-0.233	0.096	-2.436	0.016
Mn	0.197	0.078	0.197	0.078	2.528	0.012

CONCLUSIONS

In this study, different multivariate statistical techniques were successfully used to evaluate inorganic arsenic occurrence in Rybnik Reservoir water. The results obtained confirmed the fact that parameters mostly associated with total and speciated arsenic were: T, pH, TDS, PO₄³⁻, Fe, and Mn. Three significant PCs explained only 57% of total data variance. Factors PC1, PC2 and PC3 were probably the result of arsenic leaching from bottom sediments together with other elements (in the first factor), arsenic co-precipitation with PO₄³⁻, Fe and Mn (in the third factor) and regulation of these processes by pH, T and TDS concentration (in the second factor). Positions of TDS, pH and T in PC2 may reflect their distinguishable characteristics in comparison to the other parameters. This observation is also supported by a high positive dependence of 0.78 between pH and T in correlation matrix. Our primary conclusion from multiple regression analysis is that a large proportion of the variance in the measured fraction of total inorganic arsenic present as As^{Tot} (AsIII + AsV) can be explained by pH and T. Eight most influential water parameters were used to develop prediction model of As contamination. Squared multiple correlation coefficient R² indicates that these eight contamination predictors (T, pH, TDS, PO₄³⁻, Cr, Cu, Fe, Mn) explain only 34% of the variation, so the model presented does not entirely reflect investigated phenomenon. Perhaps other factors, such as, for example, redox potential, composition of geological substratum, and microbiological activity are more likely to be responsible for arsenic occurrence in Rybnik Reservoir water. Consequently, a more detailed geochemical and hydrochemical study of this dam reservoir is required before this model can be verified. It has been found that arsenic vertical distribution in dam reservoir is controlled by some form of solid-solution interaction. Leaching from sediments was probably responsible for elevated arsenic concentrations in near-bottom water layer. These assumptions suggest that water subjected to arsenic speciation analysis should be treated as triphase arrangement: water – suspension – bottom deposit, and should include separate regulations for the state of the cleanness of these three separate phases.

The observation of the natural cycle of arsenic in water reservoirs will broaden knowledge of its mobility, interactions with other elements, bioavailability and will further support technology of its removal. Multivariate analysis should serve as a reference in research on aquatic ecosystems to support environmental protection and engineering.

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WIELOWYMIAROWA ANALIZA STATYSTYCZNA WYSTĘPOWANIA ARSENU W ZBIORNIKU RYBNICKIM

Do analizy dużego zbioru danych pochodzących z półrocznego monitoringu wody Zbiornika Rybnickiego zastosowano popularne techniki statystyczne takie jak: macierz korelacji rang Spearmana, analiza głównych składowych (PCA) oraz regresja wieloraka. Próbkę wody do badań pobierano z 9 różnych stanowisk rozmieszczonych wzdłuż głównej osi zbiornika i testowano pod kątem 14 wybranych parametrów: stężeń współwystępujących pierwiastków, jonów oraz parametrów fizykochemicznych. Celem pracy była ocena wpływu tych parametrów na występowanie arsenu nieorganicznego w wodzie Zbiornika Rybnickiego za pomocą wielowymiarowych metod statystycznych. W pracy zamieszczono także wyniki przestrzennego rozkładu arsenu w zbiorniku Elektrowni Rybnik. Stężenia nieorganicznych form arsenu As(III), As(V) oznaczano metodą generowania wodorków (HG-AAS) wykorzystując spektrometr absorpcji atomowej SpectraAA 880 (Varian), rozbudowany o układ do generacji wodorków VGA-77 oraz elektrotermiczny piec ETC-60. W celu znalezienia korelacji między całkowitym arsenem nieorganicznym (As^{Tot}), a innymi parametrami wykonano macierz korelacji rang Spearmana. Wyniki tej analizy sugerują, że As był dodatnio skorelowany z PO_4^{3-} ; Fe, TDS. Potwierdzeniem tych obserwacji były wyniki analizy PCA. Analiza głównych składowych pozwoliła na wyodrębnienie ze zbioru danych 3 głównych składowych wyjaśniających 57% całkowitej zmienności. Wartości ładunków poszczególnych czynników wskazują, że procesami, które w największym stopniu wpływały na uwalnianie oraz dystrybucję As w wodzie Zbiornika Rybnickiego były: wymywanie z osadów dennych wraz z innymi pierwiastkami takimi jak: Cu, Cd, Cr, Pb, Zn, Ni, Ca (PC1), współstrącanie z Fe, Mn, PO_4^{3-} (PC3) regulowane przez czynniki fizykochemiczne jak T czy pH (PC2). Końcowy etap analizy wyników obejmował zbudowanie modelu regresji wielorakiej. Model obejmował jedynie 8 (T, pH, PO_4^{3-} , Fe, Mn, Cr, Cu, TDS) spośród 14 wyjściowych zmiennych, które służyły jako niezależne estymatory do oszacowania stopnia zanieczyszczenia wody arsenem. Praca ta ilustruje przydatność wielowymiarowych technik statystycznych do analizy i interpretacji złożonych zbiorów danych pochodzących z badań środowiskowych.