Evaluation of well waters from Ceramic district in city of Beira in Mozambique by chemometric classification technics

Introduction

Abstract

In the Ceramic district of the city of Beira in Mozambique the drinking water became from treated piped water and from traditional wells without water treatment. Nine sampling sites of water from wells use for human consummation in the Ceramic district near a cemetery were chosen to do an evaluation of the quality of the water of the wells and check the similitudes of the water of different wells. The sampling of water from wells was done by convenience sampling attending to localization of the wells (Figure 1 and 2). The quality of the water was checked attending to their similitude in terms of the physical-chemical and microbiological parameters. The nine collected samples were then placed in the fridge [1,2].

The sampled water was then classified attending to the principal physical-chemical and microbiological analytical parameters. The physical-chemical parameters analyzed were the pH, conductivity, electrical conductivity (EC), temperature, ammonia, calcium, magnesium, iron, nitrate, nitrite, sulphate, phosphate, chemical oxygen demand (COD), silica, alkalinity, copper, barium, cadmium, cobalt, nickel, zinc, ethylbenzene, styrene, chloromethane, di chloromethane, trichloromethane, chloroethane, biphenyl, tribromomethane, total hydrocarbons C10-C12, bromodichloromethane and dibromochloromethane concentrations. The microbiological parameters analyzed are the most probable number (MPN) of fecal and total coliforms (Table 1).

A classical chemometric cluster analysis was performed in order to evaluate the quality water samples and the more statistically significant variables that contribute to the variability of the model. A supervised hierarchical and non supervised K means cluster analysis were initially performed in order to evaluate the possible number of cluster and the more statistically significative variables that influence the cluster analysis. Also a non supervised two-step cluster analysis and a discriminant analysis was also performed in order to more deeply understand the results of the initial cluster analysis [3,4]. All the multivariate analysis was done in a lot of variables with and without coliform analysis. In this multivariate analysis the variables Silica and Chloroethane were not considered for the analysis due to the fact that the values found for all the wells water were unchanged and are below the limit of detection of the analytical methodology used.

By a non-standardized hierarchical cluster analysis, a three clusters model seems to be the more adequate cluster models for the analysis of the water characteristics with and without coliform analysis. The same results are found using the method based in the linkage between groups and the Ward's method as cluster models for the analysis with the coliform analysis and different results were found in the analysis without the coliform analysis. A more stable model with two clusters with a great number of statistically significative variables was found with the two clusters model. The two-step cluster analysis allows to confirm that the two-cluster model is the most adequate model.

References

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2. Ahmet S. Üçişik and Philip Rushbrook, The impact of cemeteries on the environment and public health - An introductory briefing. World Health Organization (WHO) – Regional Office for Europe, 1998. p. 1-11.
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4. El-Rawy, Mustafa; Fathi, Heba; Abdalla, Fathy, Alshehri, Fahad and Eldee, Hazem, An Integrated Principal Component and Hierarchical Cluster Analysis Approach for Groundwater Quality Assessment in Jazan, Saudi Arabia: Water 2023. 15: p. 1466-1483.

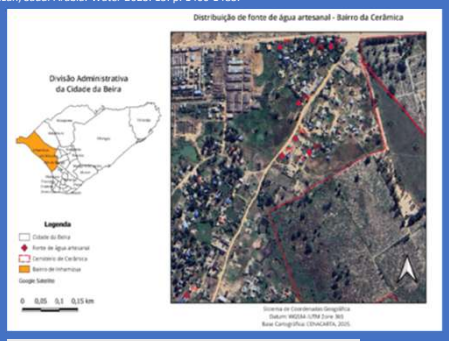


Figure 1. The map of the city of Beira in the Sofala province. The neighborhood of Inhamizua and the Cerâmica cemetery is highlighted.

Figure 2. Images of the chosen nine water wells (WW).

Table 1. Characteristics of 9 water wells samples obtained from wells in Sofala province, neighbourhood of Inhamizua near the Cerâmica cemetery

Property	WW1	WW2	WW3	WW4	WW5	WW6	WW7	WW8	WW9
pH	5.55	5.20	6.91	4.77	5.65	6.50	6.22	6.86	6.49
Conductivity (S/cm)	0.24	0.23	0.40	0.18	0.22	0.23	0.32	0.25	0.23
Ammonia (mg/L)	0.18	0.015	0.19	0.02	0.03	0.03	0.01	0.05	0.005
Ca (mg/L)	0.21	0.02	0.43	0.10	0.15	0	0	0	0
Mg (mg/L)	0.77	0.76	0.82	1.03	0.80	0.88	0.66	1.37	1.06
Fe (mg/L)	0	0.09	0.09	0.05	0.03	0.03	0.01	0.04	0.47
Nitrate (mg/L)	17.5	12.4	6.8	15.55	16.5	2.4	6.2	1.55	3.1
Nitrite (mg/L)	0.01	0.01	0.001	0.001	0.007	0.003	0.02	0.0005	0.006
Sulfate (mg/L)	0	1	5	1	7	0.14	27	18	39.5
Phosphate (mg/L)	0.17	0.25	0.12	0.11	0.13	0.14	0.11	0.16	0.06
DOO (mg/L)	4	1.5	27	8	2	4	17	12.5	13.5
Silica (mg/L)	2	2	2	2	2	2	2	2	2
Alkalinity (mg/L)	22.5	7.5	10	0	2	2.5	15	47.5	45
EC Temperature (mC)	19.5	19.7	19.6	19.7	19.8	19.6	19.9	19.5	19.8
Co (mg/L)	0.003	0.003	0.003	0.003	0.003	0.004	0.003	0.003	0.003
Ba (mg/L)	0.41	0.33	0.4	0.15	0.31	0.17	0.34	0.18	0.16
Cd (mg/L)	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.003	0.0004	0.0004
Co (mg/L)	7.2	3	1	1.7	2	1	4.6	1	3.3
Ni (mg/L)	0.012	0.013	0.09	0.002	0.004	7.8	3.7	2	2.9
Pb (mg/L)	0.005	0.008	0.14	0.012	0.005	0.005	0.008	0.006	0.02
Ethylbenzene (µg/L)	0.22	0.14	0.17	0.11	0.11	0.19	0.1	0.1	0.1
Styrene µg/L	2	2.2	1.9	1.3	0.89	1.3	0.17	1.1	1.3
Chloromethane (µg/L)	1.3	1.2	1.2	1.1	0.83	0.62	0.2	0.71	0.92
Dichloromethane (µg/L)	5.9	6.2	6.6	5.3	2.7	4.1	2.3	3.5	3.9
Trichloromethane (µg/L)	0.2	0.2	0.2	0.2	0.2	0.2	0.83	0.2	0.2
Chloroethane (µg/L)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Biphenyl (µg/L)	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Tribromomethane (µg/L)	0.1	0.1	0.1	0.1	0.1	0.22	0.1	0.1	0.1
HTP C10-C12 (µg/L)	0	0	0	0	0	0	0	0	0
Bromodichloromethane (µg/L)	0.1	0.1	0.1	0.1	0.1	0.79	0.1	0.1	0.1
Dibromochloromethane	0.1	0.1	0.1	0.1	0.1	0.89	0.1	0.1	0.1
Total Coliforms (MNP)	460	70	154	336	172	36	72	28	28
Fecal Coliforms (MNP)	10	6	2	2	2	0	0	0	0

Cluster analysis

Hierarchical unsupervised cluster analysis

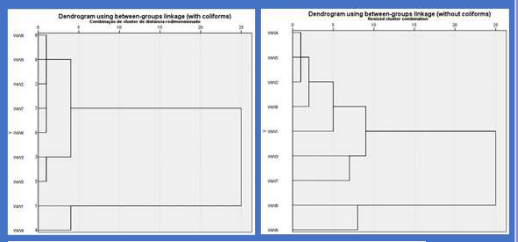


Figure 3 – Dendograms obtained in the hierarchical cluster analysis of the water wells samples with and without coliform analysis.

Table 2 – Clusters and respectively composition found in the hierarchical cluster analysis of the 9 samples of well water, with and without coliform analysis of well water, using non-standardized between-group linkage method.

Clusters (with coliforms)	Samples in the cluster
Cluster 1	WW2, WW4, WW7, WW8, WW9
Cluster 2	WW3, WW5
Cluster 3	WW1, WW6

Clusters (without coliforms)	Samples in the cluster	In Scaling	Samples in the cluster
Cluster 1	WW1, WW2, WW4, WW5, WW6	Cluster 1A	WW2, WW4, WW5, WW6
		Cluster 1B	WW1
Cluster 2	WW3, WW7	---	---
Cluster 3	WW8, WW9	---	---

- ✓ A 3 cluster model are the more adequate model to evaluate the 9 samples with and without the coliform analysis of the well waters.
- ✓ Only for the unsupervised hierarchical cluster model without coliform analysis it's possible that a 4 cluster model could be the best model.
- ✓ A different composition of the clusters is found for the cluster models with and without coliform analysis.

K means supervised cluster analysis

Table 3 – ANOVA table obtained with 3 clusters by supervised K means cluster analysis of the 9 samples with and without coliforms analysis.

Property (with coliform analysis)	Cluster Mean Square	gl	Error Mean Square	gl	Z	Significance (p ≤ 0.05)
pH	1.4	2	0.40	6	3.4	0.104
Conductivity (S/cm)	0.004	2	0.004	6	1.1	0.384
Ammonia (mg/L)	0.01	2	0.004	6	2.5	0.161
Ca (mg/L)	0.007	2	0.03	6	0.27	0.770
Mg (mg/L)	0.02	2	0.212	6	0.09	0.913
Fe (mg/L)	0.006	2	0.03	6	0.21	0.814
Nitrate (mg/L)	71.2	2	31.0	6	2.3	0.182
Nitrite (mg/L)	0.00	2	0.000	6	0.62	0.569
Sulfate (mg/L)	141.0	2	221.1	6	0.64	0.561
Phosphate (mg/L)	0.001	2	0.003	6	0.33	0.733
DOO (mg/L)	24.0	2	85.8	6	0.28	0.768
Silica (mg/L)	0.000	2	0.000	6	---	---
Alkalinity (mg/L)	257.3	2	611.4	6	0.42	0.674
EC Temperature (ºC)	0.02	2	0.020	6	0.89	0.459
Co (mg/L)	0.000	2	0.000	6	0.11	0.897
Ba (mg/L)	0.02	2	0.010	6	1.8	0.247
Cd (mg/L)	0.000	2	0.000	6	0.11	0.900
Co (mg/L)	2.6	2	1.3	6	1.8	0.240
Ni (mg/L)	4.3	2	8.0	6	0.54	0.610
Pb (mg/L)	0.000	2	0.000	6	0.11	0.902
Ethylbenzene (µg/L)	0.004	2	0.001	6	2.8	0.135
Styrene µg/L	0.2	2	.44	6	0.54	0.610
Chloromethane (µg/L)	0.13	2	.12	6	1.0	0.409
Dichloromethane (µg/L)	1.7	2	2.70	6	0.61	0.574
Trichloromethane (µg/L)	0.006	2	0.05	6	0.11	0.897
Chloroethane (µg/L)	0.000	2	0.000	6	---	---
Biphenyl (µg/L)	0.000	2	0.000	---	---	---
Tribromomethane (µg/L)	0.000	2	0.002	6	0.11	0.897
HTP C10-C12 (µg/L)	44.4	2	0.000	6	---	---
Bromodichloromethane (µg/L)	0.008	2	0.068	6	0.11	0.897
Dibromochloromethane	0.01	2	0.089	6	0.11	0.897
Total Coliforms (MNP)	**42496,0**	**2**	**1574.7**	6	21.1	**0.002**
Fecal Coliforms (MNP)	**12,3**	**2**	**1.0**	6	6.5	**0.031**

Property (without coliform analysis)	Cluster Mean Square	gl	Error Mean Square	gl	Z	Significance (p ≤ 0.05)
pH	1.52	2	0.3	6	4.4	0.066
Conductivity (S/cm)	**0.01**	2	**0.002**	6	6.8	**0.029**
Ammonia (mg/L)	0.003	2	0.006	6	0.4	0.679
Ca (mg/L)	0.02	2	0.02	6	1.1	0.383
Mg (mg/L)	0.41	2	0.08	6	5.0	0.053
Fe (mg/L)	0.04	2	0.02	6	2.1	0.210
Nitrate (mg/L)	48.0	2	25.4	6	3.5	0.100
Nitrite (mg/L)	0.000	2	0.000	6	0.5	0.645
Sulfate (mg/L)	**150.4**	2	**84.6**	6	6.5	**0.031**
Phosphate (mg/L)	0.002	2	0.001	6	0.9	0.458
DOO (mg/L)	**146.0**	2	**12.8**	6	19.2	**0.002**
Silica (mg/L)	**1741.3**	2	**116.7**	6	14.9	**0.005**
Alkalinity (mg/L)	0.007	2	0.02	6	0.3	0.761
EC Temperature (ºC)	0.000	2	0.000	6	0.3	0.729
Co (mg/L)	0.000	2	0.000	6	2.4	0.176
Ba (mg/L)	0.000	2	0.000	6	2.3	0.179
Cd (mg/L)	1.1	2	7.7	6	0.3	0.771
Co (mg/L)	0.5	2	9.3	6	0.06	0.942
Ni (mg/L)	0.003	2	0.001	6	2.3	0.181
Pb (mg/L)	0.002	2	0.002	6	1.0	0.412
Ethylbenzene (µg/L)	0.2	2	0.5	6	0.47	0.648
Styrene µg/L	0.08	2	0.1	6	0.56	0.600
Chloromethane (µg/L)	0.9	2	2.9	6	0.3	0.740
Dichloromethane (µg/L)	0.02	2	0.05	6	0.3	0.729
Trichloromethane (µg/L)	0.000	2	0.000	6	0.3	0.729
Chloroethane (µg/L)	0.001	2	0.002	6	0.3	0.729
Biphenyl (µg/L)	4.4	2	13.3	6	0.3	0.729
Tribromomethane (µg/L)	0.02	2	0.06	6	0.3	0.729
HTP C10-C12 (µg/L)	0.03	2	0.08	6	0.3	0.729
Bromodichloromethane (µg/L)	0.5	2	0.3	6	4.4	0.066
Dibromochloromethane	**0.01**	2	**0.002**	6	**6.8**	**0.029**

Two step supervised cluster analysis

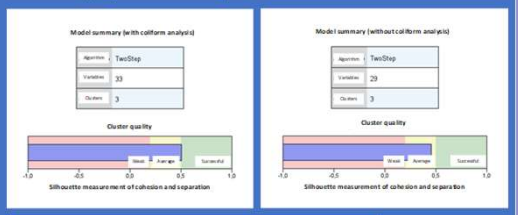


Figure 4 – Model summary with 3 clusters of supervised two-step cluster analysis of the water wells samples with and without microbiological characteristics.

Table 4 – Importance predictor from 0 to 1 obtained with 3 clusters by supervised two step cluster analysis of the 9 samples with and without coliforms analysis.

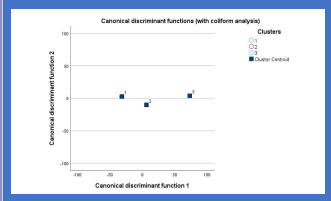
Property (with coliforms analysis)	Importance
Phosphate (mg/L)	0.050
Nitrite (mg/L)	0.056
Cd (mg/L)	0.057
Fe (mg/L)	0.058
pH	0.059
Alkalinity (mg/L)	0.028
Mg (mg/L)	0.037
Co (mg/L)	0.037
DOO (mg/L)	0.053
Nitrate (mg/L)	0.058
Sulfate (mg/L)	0.075
Styrene µg/L	0.097
Conductivity (S/cm)	0.100
Chloromethane (µg/L)	0.120
Total Coliforms (MNP)	0.124
EC Temperature (ºC)	0.124
Faecal Coliforms (MNP)	0.125
Dichloromethane (µg/L)	0.140
Zn (mg/L)	0.147
Chloroethane (µg/L)	0.155
Biphenyl (µg/L)	0.155
HTP C10-C12 (µg/L)	0.155
Ba (mg/L)	0.216
Ca (mg/L)	0.269
Ni (mg/L)	0.383
Ethylbenzene (µg/L)	0.511
Ammonia (mg/L)	1

Property (without coliforms analysis)	Importance
Conductivity (S/cm)	0.016
Nitrite (mg/L)	0.022
Zn (mg/L)	0.027
Biphenyl (µg/L)	0.029
HTP C10-C12 (µg/L)	0.029
EC Temperature (ºC)	0.031
Co (µg/L)	0.039
Phosphate (mg/L)	0.054
DOO (mg/L)	0.055
Fe (mg/L)	0.056
Ammonia (mg/L)	0.070
Cd (mg/L)	0.078
Mg (mg/L)	0.088
Ba (mg/L)	0.100
Styrene (µg/L)	0.133
pH	0.148
Ca (mg/L)	0.153
Dichloromethane (µg/L)	0.156
Chloroethane (µg/L)	0.175
Alkalinity (mg/L)	0.190
Chloromethane (µg/L)	0.245
Nitrate (mg/L)	0.366
Sulfate (mg/L)	0.487
Ni (mg/L)	1

- ✓ By supervised two step cluster analysis of the water samples with and without coliform analysis were respectively obtained a successful and an average analysis with a 3 cluster model.
- ✓ By supervised K means cluster analysis with the coliform analysis models the variables that contribute more for the model are the Total and Faecal Coliforms and for the analysis without coliform analysis are the DQO, Alkalinity, Conductivity and Sulphate.
- ✓ By supervised step cluster analysis in the analysis with coliform analysis the 3 more important predictors are the Ammonia, Ethylbenzene and Ni and without coliform analysis are the Ni, Sulphate and Nitrate.

Discriminant analysis

Discriminant analysis with 3 clusters



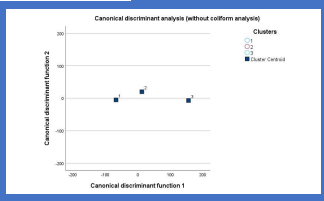


Figure 5 – Discriminant plot found by discriminant analysis with 3 clusters for the analysis with and without coliform analysis.

Table 5 – Statistical tests about the discriminating capacity of the discriminant analysis with 3 clusters of for the analysis with and without coliform analysis.

Property (with coliform analysis)	Wilk's lambda	F	gl1	gl2	Significance (p ≤ 0.05)
pH	0.404	4.4	2	6	0.066
Conductivity (S/cm)	**0.106**	**6.8**	2	6	**0.029**
Ammonia (mg/L)	0.879	0.4	2	6	0.679
Ca (mg/L)	0.726	1.1	2	6	0.383
Mg (mg/L)	0.376	5.0	2	6	0.053
Fe (mg/L)	0.594	2.0	2	6	0.210
Nitrate (mg/L)	0.464	3.5	2	6	0.100
Nitrite (mg/L)	0.864	0.47	2	6	0.645
Sulphate (mg/L)	**0.316**	**6.5**	2	6	**0.031**
Phosphate (mg/L)	0.771	0.89	2	6	0.458
DOO (mg/L)	**0.135**	**19.2**	2	6	**0.002**
Alkalinity (mg/L)	**0.167**	**14.9**	2	6	**0.005**
EC Temperature (ºC)	0.913	0.29	2	6	0.761
Co (mg/L)	0.900	0.33	2	6	0.729
Ba (mg/L)	0.561	2.4	2	6	0.176
Cd (mg/L)	0.563	2.3	2	6	0.179
Co (mg/L)	0.771	0.77	2	6	0.771
Ni (mg/L)	0.980	0.06	2	6	0.942
Zn (mg/L)	0.565	2.31	2	6	0.181
Ethylbenzene (µg/L)	0.744	1.03	2	6	0.412
Styrene µg/L	0.865	0.47	2	6	0.648
Chloromethane (µg/L)	0.843	0.56	2	6	0.600
Dichloromethane (µg/L)	0.904	0.32	2	6	0.740
Trichloromethane (µg/L)	0.900	0.33	2	6	0.729
Biphenyl (µg/L)	0.900	0.33	2	6	0.729
Tribromomethane (µg/L)	0.900	0.33	2	6	0.729
HTP C10-C12 (µg/L)	0.900	0.33	2	6	0.729
Bromodichloromethane (µg/L)	0.900	0.33	2	6	0.729
Dibromochloromethane	0.900	0.33	2	6	0.729

Property (without coliform analysis)	Wilk's lambda	F	gl1	gl2	Significance (p ≤ 0.05)
pH	0.404	4.4	2	6	0.066
Conductivity (S/cm)	**0.106**	**6.8**	2	6	**0.029**
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Biphenyl (µg/L)	0.900	0.33	2	6	0.729
Tribromomethane (µg/L)	0.900	0.33	2	6	0.729
HTP C10-C12 (µg/L)	0.900	0.33	2	6	0.729
Bromodichloromethane (µg/L)	0.900	0.33	2	6	0.729
Dibromochloromethane	0.900	0.33	2	6	0.729

Table 6 – Average and standard deviation of the well waters clusters in the third clusters observed by discriminant analysis of the variables with and without coliform analysis.

Property (with coliform analysis)	Cluster 1	Cluster 2	Cluster 3	Total
pH	6.3 (0.6)	6.3 (0.9)	5.0 (0.3)	6.0 (0.8)
Conductivity (S/cm)	0.3 (0.04)	0.3 (0.1)	0.2 (0.04)	0.2 (0.06)
Ammonia (mg/L)	0.02 (0.02)	0.3 (0.1)	0.1 (0.1)	0.08 (0.07)
Ca (mg/L)	0.004 (0.009)	0.3 (0.2)	0.2 (0.08)	0.1 (0.1)
Mg (mg/L)	3 (0.6)	0.8 (0.02)	0.9 (0.02)	0.9 (0.4)
Fe (mg/L)	0.1 (0.2)	0.06 (0.04)	0.03 (0.04)	0.09 (0.2)
Nitrate (mg/L)	5 (4.4)	11.7 (8.5)	16.5 (0.3)	9.3 (6.4)
Nitrite (mg/L)	0.007 (0.007)	0.004 (0.004)	0.006 (0.006)	0.006 (0.006)
Sulphate (mg/L)	17.2 (16.9)	6 (0.4)	0.5 (0.7)	11.0 (14.2)
Phosphate (mg/L)	0.1 (0.07)	0.1 (0.007)	0.1 (0.05)	0.1 (0.05)
DOO (mg/L)	9.7 (6.6)	14.5 (17.7)	8.0 (2.8)	9.9 (8.4)
Alkalinity (mg/L)	27.5 (27.8)	16.0 (19.8)	11.3 (16.0)	21.3 (22.9)
EC Temperature (ºC)	19.7 (0.2)	19.8 (0.1)	19.7 (0.1)	19.7 (0.1)
Co (mg/L)	**0.003 (0.003)**	**0.003 (0.000)**	0.003 (0.000)	0.003 (0.0002)
Ba (mg/L)	0.2 (0.09)	0.4 (0.000)	0.3 (0.2)	0.3 (0.1)
Cd (mg/L)	0.003 (0.0009)	0.004 (0.000)	**0.0004 (0.0000)**	**0.0006 (0.0007)**
Co (mg/L)	3.4 (2.6)	1.5 (0.7)	4.5 (3.9)	3.2 (2.5)
Ni (mg/L)	3.3 (2.9)	0.04 (0.06)	0.007 (0.007)	1.8 (2.7)
Zn (mg/L)	0.008 (0.004)	0.07 (0.1)	0.009 (0.005)	0.02 (0.04)
Ethylbenzene (µg/L)	0.1 (0.04)	0.1 (0.06)	0.2 (0.08)	0.1 (0.05)
Styrene µg/L	1.2 (0.7)	1.4 (0.7)	1.7 (0.5)	1.3 (0.6)
Chloromethane (µg/L)	0.7 (0.4)	1.0 (0.1)	1.2 (0.1)	0.9 (0.4)
Dichloromethane (µg/L)	0.7 (0.4)	4.7 (2.8)	5.6 (0.4)	4.5 (1.6)
Trichloromethane (µg/L)	0.3 (0.3)	0.2 (0.0)	0.2 (0.0)	0.3 (0.2)
Biphenyl (µg/L)	0.01 (0.00)	0.01 (0.00)	0.02 (0.007)	0.01 (0.003)
Tribromomethane (µg/L)	0.1 (0.05)	0.1 (0.0)	0.1 (0.0)	0.1 (0.04)
HTP C10-C12 (µg/L)	**0.000 (0.000)**	**0.000 (0.000)**	5.0 (7.1)	1.1 (3.1)
Bromodichloromethane (µg/L)	0.2 (0.3)	0.1 (0.0)	0.1 (0.0)	0.2 (0.2)
Dibromochloromethane	0.3 (0.4)	0.1 (0.0)	0.1 (0.0)	0.2 (0.3)
Total Coliforms (MNP)	**46.8 (21.3)**	**163.0 (0.0)**	**398.0 (87.7)**	**150.7 (152.3)**
Faecal Coliforms (MNP)	2.2 (2.7)	2.0 (0.0)	6.0 (5.7)	2.4 (3.4)

Property (without coliform analysis)	Cluster 1	Cluster 2	Cluster 3	Total
pH	5.5 (0.7)	6.6 (0.5)	6.7 (0.3)	5.6 (0.8)
Conductivity (S/cm)	0.2 (0.04)	0.4 (0.05)	0.2 (0.02)	0.3 (0.06)
Ammonia (mg/L)	0.06 (0.08)	0.1 (0.1)	0.03 (0.02)	0.06 (0.07)
Ca (mg/L)	0.09 (0.09)	0.2 (0.3)	**0.000 (0.000)**	0.1 (0.1)
Mg (mg/L)	0.8 (0.1)	0.7 (0.1)	1.5 (0.6)	0.9 (0.4)
Fe (mg/L)	0.04 (0.03)	0.05 (0.05)	0.3 (0.3)	0.09 (0.2)
Nitrate (mg/L)	12.9 (6.1)	6.5 (0.4)	2.3 (1.1)	9.1 (6.4)
Nitrite (mg/L)	0.006 (0.004)	0.009 (0.01)	0.003 (0.004)	0.006 (0.006)
Sulphate (mg/L)	0.7 (0.9)	38.0 (19.2)	28.8 (5.2)	11.0 (14.2)
Phosphate (mg/L)	0.2 (0.06)	0.1 (0.007)	0.1 (0.07)	0.1 (0.05)
DOO (mg/L)	3.9 (2.6)	22.0 (7.1)	13.0 (0.7)	9.9 (8.4)
Alkalinity (mg/L)	6.9 (9.2)	**22.5 (10.6)**	**56.3 (8.2)**	**21.3 (22.9)**
EC Temperature (ºC)	**19.7 (0.1)**	19.8 (0.1)	19.7 (0.2)	19.7 (0.1)
Co (mg/L)	0.003 (0.0003)	0.003 (0.000)	0.003 (0.000)	0.003 (0.0002)
Ba (mg/L)	0.3 (0.1)	0.4 (0.04)	0.2 (0.01)	0.3 (0.1)
Cd (mg/L)	**0.0004 (0.000001)**	**0.002 (0.002)**	**0.0004 (0.0000)**	**0.0006 (0.0007)**
Co (mg/L)	3.8 (3.1)	2.8 (2.6)	2.1 (1.8)	3.2 (2.5)
Ni (mg/L)	1.6 (1.5)	1.9 (2.6)	2.5 (0.6)	1.8 (2.7)
Zn (mg/L)	0.007 (0.003)	0.07 (0.09)	0.01 (0.006)	0.02 (0.04)
Ethylbenzene (µg/L)	0.2 (0.05)	0.1 (0.05)	0.1 (0.00)	0.1 (0.05)
Styrene µg/L	1.5 (0.5)	1.0 (1.2)	1.2 (0.4)	1.4 (0.6)
Chloromethane (µg/L)	1 (0.3)	0.7 (0.7)	0.8 (0.2)	0.9 (0.4)
Dichloromethane (µg/L)	4.8 (1.4)	4.5 (3.0)	1.7 (0.3)	4.5 (1.6)
Trichloromethane (µg/L)	0.3 (0.3)	0.2 (0.0)	0.2(0.000)	0.3 (0.2)
Biphenyl (µg/L)	0.01 (0.005)	0.01 (0.00)	0.01 (0.00)	0.01 (0.003)
Tribromomethane (µg/L)	0.1 (0.05)	0.1 (0.0)	0.1 (0.00)	0.1 (0.04)
HTP C10-C12 (µg/L)	2.0 (4.5)	**0.000 (0.000)**	**0.000 (0.000)**	1.1 (3.1)
Bromodichloromethane (µg/L)	0.2 (0.3)	0.1 (0.0)	0.01 (0.00)	0.2 (0.2)
Dibromochloromethane	0.3 (0.4)	0.1 (0.0)	0.01 (0.00)	0.2 (0.3)

- ✓ By the analysis of the discriminant plots by analysis of the data with and without coliform analysis the clusters 1 and 2 closer and the cluster 3 is isolated and further away of the other 2 clusters.
- ✓ By the analysis of statistical texts found by discriminant analysis with 3 cl