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Study of water contaminated by mining and its environmental impact in the communities of the hydrographic basin of the opamayo river of the Huancavelica Region

Luis Quispealaya Armas [(1)], Luz marina AcharteLume[(1)] Amadeo Enriquez Donaires[(1)]D.Lovera[(2)], W.Pardavé[(3)], J.M.Asto[(1)] , A. Torres[(2)], Y.Santamaría[(4)]

[1](Department of mining and metallurgy, Universidad de Huancavélica, Perú)
[2](Department of metallurgical Engineering, Universidad Nacional de San Marcos, Perú)
[3](Applied Research Environmental Group, Universidad de Santander, Colombia.)
4(Department of metallurgical Engineering and material science, Universidad Industrial de Santander, Colombia)
Corresponding Author: Luis Quispealaya Armas

Abstract: *The drainage of mining waters from underground polymetallic mining activity has led to the study of water polluted by mining and its environmental impact in the communities of the Opamayo River Basin of the Huancavelica region, to assess the polluting metal species ; Therefore, the concentrations of the elements existing in waters of the basin and some of its main tributaries were determined, in order to know the real risk generated in the area, for the analysis of these metals the analytical method of spectrophotometry was implemented. Atomic absorption flames, achieving the characteristic concentration according to the equipment Atomic Absorption Spectrophotometer BRAND THERMOCIENTIFIC ISO 3000 SERIES of the following elements: Manganese (Mn = 0.02mg / L), lead (Pb = 0.07 mg / L), Zinc (Zn = 0.01mg / L), Copper (Cu = 0.033 mg / L), Aluminum (Al = 0.03 mg / L), Cadmium (Cd = 0.013 mg / L), Chromium (Cr = 0.05 mg / L) and Iron (Fe = 0.05mg / L) was found below the maximum level allowed by Supreme Decree DS No. 0015-2015-MINAM Manganese (Mn = 0.5mg / L), Lead (Pb = 0 , 05 mg / L), Zinc (Zn = 5.0 mg / L), Copper (Cu = 2 mg / L), Aluminum (Al = 5 mg / L), Cadmium (Cd = 0.05 mg / L) , Chromium (Cr = 0.05 mg / L) and Iron (Fe = 5 mg / L). A digestion method in acid medium (HNO_3 and 50% HCL) was also optimized, with the DIGIPREP MS brand Digestor block equipment and the digestion was carried out during 240 min at the T ° of 85ºC, showing results that decrease due to dilution for the greater water flow.*

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I. Introduction

The hydrographic basins of the Huancavelica region are receiving the dumping of mining extractive activities, in this respect (steel, 2018) refers that the point sources are in specific places, they are identifiable, monitoriables and adjustable. The Rio Opamayo River basin is located in the upper area of the south west of the province of Angaraes, Huancavelica region, in the vicinity of mining sites in activity, such as recovered, Kolpa, Cambalache and Julcani, whose purpose Main is to extract minerals by means of conventional exploitation favorable to the human well-being, on the contrary, it is of concern for the ecosystem. (Alcantara, 2015)

The Opamayo River water study was a priority topic of environmental research to know the existence of heavy metals and served to generate knowledge, contributing to academic knowledge and environmental sciences. Heavy metal ions that enter the aquatic environment mainly by direct discharges from industrial sources is one of the aspects to consider of importance. (Aliaga, 2010), (Calla, 2010), (Dolmo, 2010).

The most vulnerable populations inhabit both banks of the Opamayo River watershed, whose main source of water supply is for their agricultural and livestock activities, and in some measure affect human health. (Quispealaya, 2018). The analysis to know the impact results was the easy-to-use analytical method for the proper detection of concentrations in parts per million (ppm) of the elements Mn, Pb, Zn, Cu, Al, Cd, Cr and Fe in water samples according to the values maximum Established by the Supreme Decree D. S n ° 015-2015-MINAM and the World Health Organization (WHO).

II. Materials And Methods

Materials

Laboratory materials considered: Fiolas, pipettes, Micropipettes, beakers, test tube, squirt bottle, suction bulb.
As to the standards used were:

-Standards of (Pb, Cu, As, Mn, Se, Sb, Si)
-Nitric acid (HNO3) at 67.5%..... P.a.
-Hydrochloric acid (HCL) at 37%-----P.A.

Methods

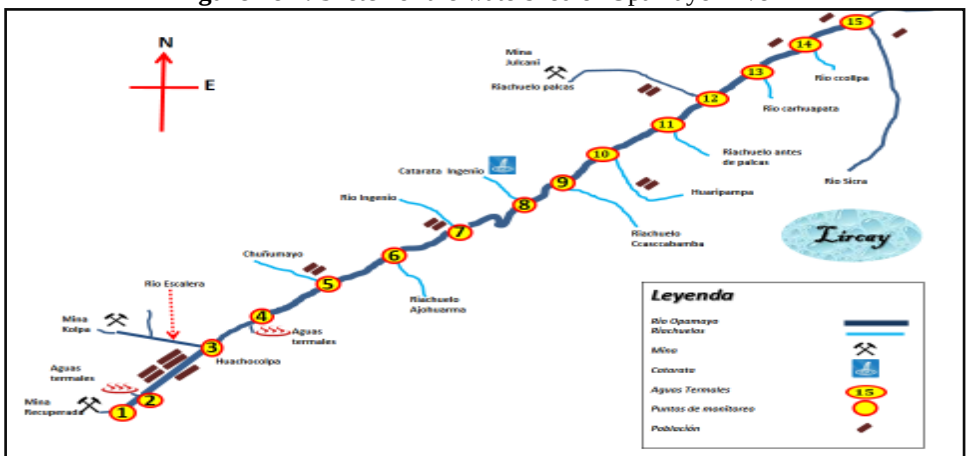
-*Sampling process* includes the reading coordinates and dimensions with the GPS. Water samples were taken with 3 replicates per point, the preservative was added, stabilized with HNO_3 to 3%, we proceeded to the measurement of established parameters: PH, conductivity, dissolved oxygen, temperature among others and then we proceeded to labelling or Labeled Samples. See Figure 1

-*Sample transport process.*

-*Sample entry to the laboratory*. Samples are delivered to the laboratory and the sample is received and registered.

-*Laboratory analysis process.*

Figure no 1. Sketch of the watershed of Opamayo River

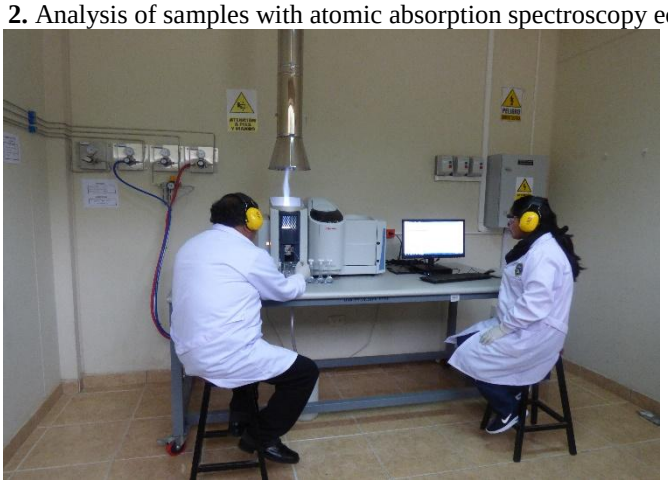


III. Discussion of Results

Process of analysis by atomic absorption spectroscopy Flame

The analysis of samples from the different sampling points along the Opamayo River watershed was carried out in the chemistry laboratory of the Faculty of Engineering of Environmental Civil mines of the National University of Huancavelica, with the use of the team Atomic Absorption spectroscopy brand THERMOCIENTIFIC ICE 3000 series. See Figure 2.

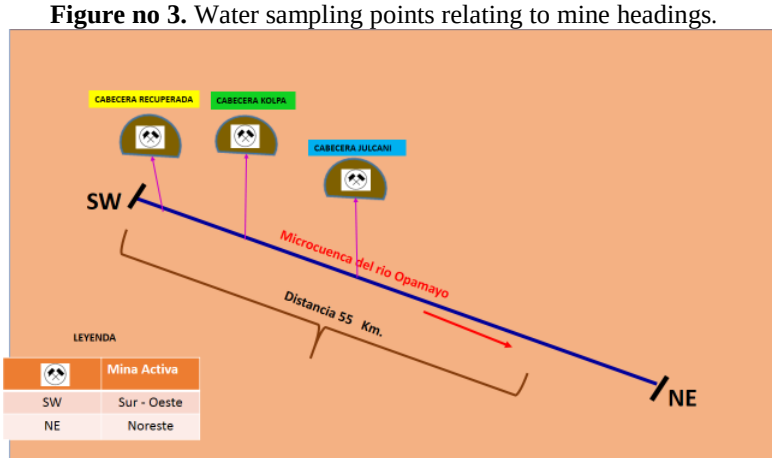
Figure no 2. Analysis of samples with atomic absorption spectroscopy equipment



Water as a reference obtained from the head of Mina.

The water samples as a reference was collected from the headwaters recovered mine (UTM coordinates e: 502992 N: 8548832 altitude 4500 M.A.S.L.), Kolpa (UTM coordinates e: 498730 N: 8552109 altitude 4.622 meters m) and Julcani (UTM coordinates e: 520909 N: 8569537 Altitude 4.214 M.A.S.L.) In order to make results compared with the water samples taken at the points of the Opamayo River watershed, as shown in Figure 3.

Figure no 3. Water sampling points relating to mine headings.



The results of analysis of the water samples referring to the headings of mine were Mn with a concentration of 0.149 mg/L, Pb with 0.004 mg/L, Zn with 0.040 mg/L, Cu with 0.009 mg/L, Al with 0.243 mg/L, Cd with 0.012 mg/l , Cr with 0.037 mg/L and Fe with 0.371 mg/l, results below the maximum permissible limits, as shown in table N ° 01 and Figure 4

Table no 1. Concentration in mg/L of the elements of the water samples referring to the mine headings.

Element	Id Sample	Mn	Pb	Zn	Cu	Al	Cd	Cr	Fe	T°	pH
Reference Mine Heading		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		
		0.27	0.005	0.004	0.006	0.386	0.012	0.053	0.537		
Recovered	**PMA**	0.27	0.005	0.004	0.006	0.386	0.012	0.053	0.537	4.8	8.1
Kolpa	**PMC**	0.03	0.002	0.1	0.003	0.308	0.013	0.052	0.352	9.2	8
Julcani	**PMF**	0.146	0.005	0.015	0.019	0.035	0.012	0.005	0.226	8.1	6.98
Average		**0.004**	**0.04**	**0.009**	**0.243**	**0.012**	**0.037**	**0.371**	**7.36**		**7.69**
D.S N° 015-2015-MINAM-ECA mg/L		**0.149**	**0,05**	**5,0**	**2,0**	**5,0**	**0,01**	**0,05**	**5,0**		**5.5-9.0**

Figure no 4.*Water sampling at selected points*

Water of tributaries that flows into the hydrographic basin of the river Opamayo

Water samples of the tributaries Chuñomayo (PM5) with UTM coordinates E: 509230 N: 8565079 altitude 3.778 meters m, dam Ajuwarma (PM6) with UTM coordinates E:511469 N: 8566341 altitude 3.7070, Ingenio (PM7) with UTM coordinates e: 513170 N: 8566624 altitude 3.640, cataract wit (PM8) with UTM coordinates e: 513959 N: 8566169 altitude 3.595, Huaripampa (PM10) with UTM coordinates E:517642 N: 8565628 altitude 3.496 M.A.S.L., which flow into the basin Opamayo River Hydrographic, as shown in figure 5.

Figure no 5. Sampling points for tributaries

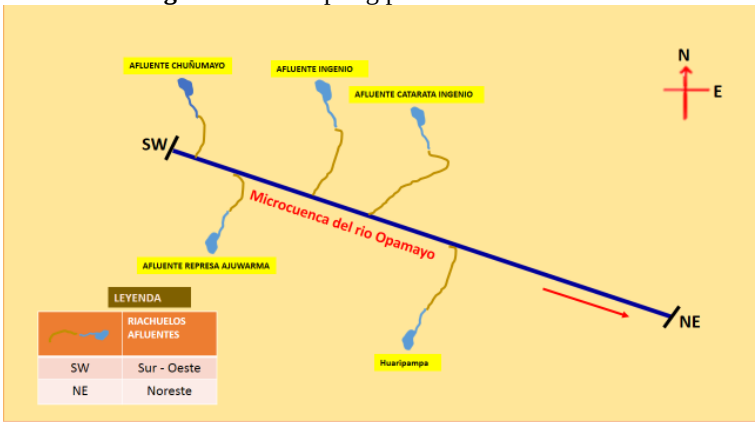


Table no 2. Concentration in mg/L of the elements of the effluent samples of the Opamayo River

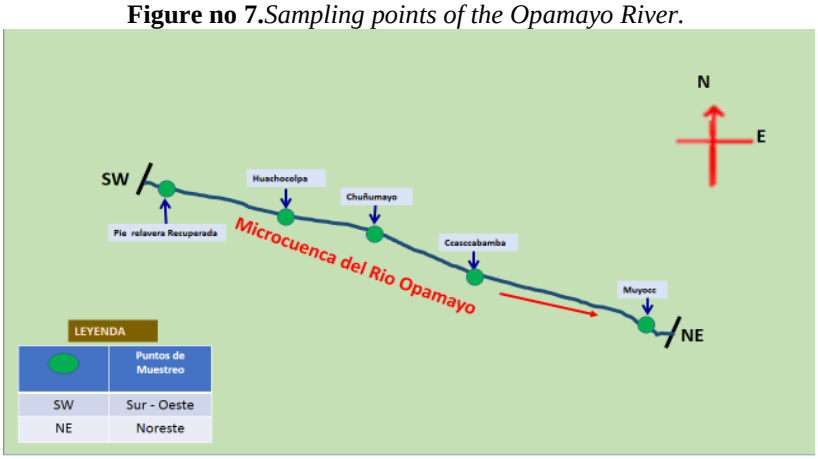
Element	Id Sample	Mn	Pb	Zn	Cu	Al	Cd	Cr	Fe	T°	pH
Affluents		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		
Chuñomayo	PM5	0.004	0.007	0.003	0.005	0.003	0.005	0.002	0.004	11.7	8,27
Represa	PM6	0.006	0.007	0.006	0.001	0.007	0.007	0.002	0.004	11.8	9.09
Ingenio	PM7	0.003	0.008	0.004	0.011	0.007	0.004	0.006	0.007	11.3	8.47
Catarata	PM8	0.004	0.004	0.004	0.006	0.005	0.007	0.002	0.006	9.2	8.66
Huaripampa	PM10	0.003	0.002	0.004	0.003	0.002	0.004	0.003	0.003	11.2	8.17
Total Average		0.006	0.004	0.005	0.005	0.006	0.003	0.005	11.04	11.04	8.53
D.S N° 002-2018-MINAM-ECA mg/L		0.004	0,3	5,0	0,4	5,0	0,05	0,1	2,0		5.5-9.0

Figure no 6. Water sampling in the effluents of the Opamayo River.

Sampling points in the Opamayo River

Water samples from the points of the Opamayo tailors River recovered (PM-P1) with UTM coordinates E: 505788 N: 8552721 altitude 4.221 meters m, Huachocolpa (PM-P3) with UTM coordinates E:505839 N: 8559502 altitu D 3.954, Chuñomayo (PM-P5) with UTM coordinates e: 509230 N: 8565079 altitude 3.778, Ccasccabamba (PM-P9) with UTM coordinates e: 517389 N: 8565731 altitude 3.516, MUYOCC (PM10) with UTM coordinates E:530160 N: 8564707 altitude 3.251 M.A.S.L., as shown in figure 7.

Figure no 7.*Sampling points of the Opamayo River.*



The results of analysis of the water samples from the points of Rio Opamayo, were Mn with a concentration of 0.120 mg/L, Pb with 0.006 mg/L, Zn with 0.333 mg/L, Cu with 0.005 mg/L, Al with 0.136 mg/L, Cd with 0.057 mg/l , Cr with 0.150 mg/L and Fe with 0.485 mg/L, the results of the metals below the permissible maximum limits are: Mn, Pb, Zn, Cu, Al and Fe, the elements that are slightly above the maximum permissible limits according to DS 002-2018-MIN AM-ECA mg/L are Cd and Cr, as shown in table # 03 and Figure 8.

Table no 3. *Results of the water analysis of the Opamayo River.*

Resultbyelement Points in OPAMAYORiver	ID MUESTRA	Mn mg/L	Pb mg/L	Zn mg/L	Cu mg/L	Al mg/L	Cd mg/L	Cr mg/L	Fe mg/L	T°	pH
Recoveredtailing	**PM-P1**	0.504	0.007	0.885	0.005	0.107	0.065	0.065	0.107	6.5	7.47
HUACHOCOLPA	**PM-P3**	0.047	0.007	0.736	0.001	0.580	0.107	0.107	0.580	12.1	7.13
CHUÑOMAYO	**PM-P5**	0.031	0.008	0.005	0.011	0.002	0.002	0.002	0.580	11.7	8.27
CCASCCABAMBA	**PM-P9**	0.011	0.004	0.007	0.006	0.002	0.002	0.002	0.580	9.7	8.54
MUYOCC	**PM-P15**	0.006	0.002	0.031	0.003	0.005	0.107	0.580	0.580	9.8	8.13
Average			**0.006**	**0.333**	**0.005**	**0.136**	**0.057**	**0.150**	**0.485**	**9.96**	**7.9**
D.S N° 002-2018-MINAM-ECA mg/L			**0.120**	**0,3**	**5,0**	**0,4**	**5,0**	**0,05**	**0,1**	**2,0**	**5.5-9.0**

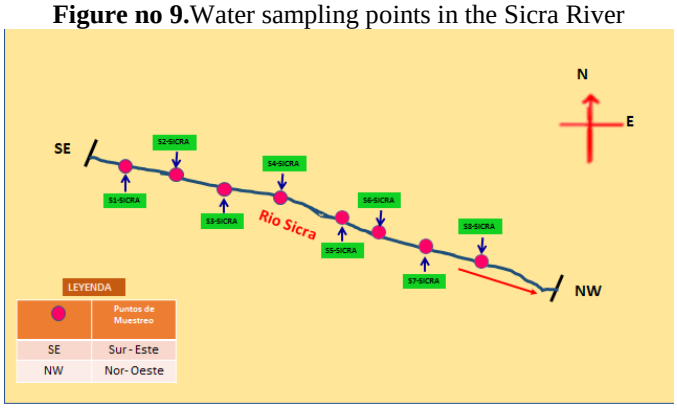
DS 002-2018-MIN AM-ECA mg/L are Cd and Cr, as shown in table # 03 and Figure 8.

Figure no 8. Project team at the sampling points of the Opamayo River

Water sampling points in the Sicra River.

Water samples from the points of the River Sicra (S1-SICRA) with UTM coordinates E: 0533448 N:8558009 altitude 3300 meters m, (S2-SICRA) with UTM coordinates E:0532622 N: 8558315 altitude 3440, (S3-SICRA) with UTM coordinates E: 0532621 N: 855831 altitude 3442, (S4-SICRA) with UTM coordinates e: 0532060 N: 8558516 altitude 3423, (S5-SICRA) with UTM coordinates E:0530910 N: 8560425 altitude 3343 M.A.S.L., (S6-SICRA) with UTM coordinates e: 0530909 N: 8560429 altitude 3341, (S7-SICRA) with UTM coordinates E:0530149 N: 8563510 altitude 3276 M.A.S.L. (S8-SICRA) with UTM coordinates E: 0530107 N: 8564004 altitude 3266 M.A.S.L., as shown in figure 9.

Figure no 9. Water sampling points in the Sicra River



The results of analysis of the water samples from the points of the Sicra River, were Mn with a concentration of 0.282 mg/L, Pb with 0.035 mg/L, Zn with 2.152 mg/L, Cu with 0.002 mg/L, Al with 2.432 mg/L, Cd with 0.918 mg/l , Cr with 0.400 mg/L and Fe with 2.097 mg/L, the results of the metals below the permissible maximum limits are: Mn, Pb, Zn, Cu, Al and Fe, the elements that are slightly above the maximum permissible limits according to DS 002-2018-MIN AM-ECA mg/L are Cd and Cr, as shown in table 4, 5 and 10.

Table no 4. Results of the water analysis of the Sicra River.

RESULT BY ELEMENT	ID SAMPLE	Cr	Al	Fe	Mn	Pb	Cu	Cd	Zn	T°	pH
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		
	S1-SICRA	0.051	0.356	1.571	0.029	0.001	0.006	0.013	0.032	11.5	6.87
	S2-SICRA	0.054	0.336	4.953	0.036	0.019	0.009	0.013	0.052	11.2	7.1
	S3-SICRA	0.052	0.249	9.105	0.056	0.004	0.007	0.014	0.33	10.5	7.5
	S4-SICRA	0.054	0.255	0.775	0.021	0.001	0.002	0.33	0.091	9.14	9.5
	S5-SICRA	0.054	0.054	0.242	0.032	0.012	0.004	0.589	1.571	9.11	6.5
	S6-SICRA	0.035	0.33	0.186	0.031	0.011	0.004	0.054	0.032	12.1	7.1
	S7-SICRA	0.052	0.321	2.998	0.046	0.008	0.005	0.001	0.054	10.5	7.5
	S8-SICRA	0.048	0.531	0.589	0.031	0.003	-0.004	0.014	**10.4**	9.12	8.1
Promedio			**2.432**	**2.097**	**0.282**	**0.035**	**0.002**	**0.918**	**2.152**		**7.5**
D.S N° 002-2018-MINAM-ECA mg/L			**0.4**	**5,0**	**5,0**	**0,5**	**0,05**	**2,0**	**0,01**		**5.5-9.0**

Figure no 10. Monitoring and sampling in the Sicra River.

Table no 5. Results of wateranalysisbyflameatomicabsorptionspectroscopy

RESULTS OF WATER ANALYSIS BY FLAME ATOMIC ABSORPTION SPECTROSCOPY									T°	pH
Samplingpoints	**Mn**	**Pb**	**Zn**	**Cu**	**Al**	**Cd**	**Cr**	**Fe**		
	mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**		
Reference head of mine	0.149	0.004	0.04	0.009	0.243	0.012	0.037	0.371	7.37	7.69
Affluents	0.004	0.006	0.004	0.005	0.005	0.006	0.003	0.005	11.04	8.53
Points in OPAMAYO River	0.12	0.006	0.333	0.005	0.136	0.057	0.15	0.485	7.96	7.9
SICRA River	0.4	2.432	2.097	0.282	0.035	0.002	0.918	2.152	10.4	7.5
D.S N° 015-2015-MINAM-ECA mg/L	**0,5**	**0,05**	**5,0**	**2,0**	**5,0**	**0,01**	**0,05**	**5,0**		**5.5-9.0**

Mine head water analyses result in average with the following concentrations of the metal elements between them, manganese (MN = 0, 149mg/L), lead (Pb = 0,004 mg/L), Zinc (Zn = 0, 040mg/L), copper (Cu = 0,009 mg/l), aluminium (Al = 0, 243mg/L), cadmium (Cd = 0.012 mg/l), chromium (Cr = 0,037 mg/l) and iron (Fe = 0, 371mg/L); The results of the tributaries that flow into the Opamayo River basin have the following concentrations of metals: manganese (mn = 0, 004mg/L), lead (Pb = 0,006 mg/l), zinc (Zn = 0, 004mg/L), copper (Cu = 0,005 mg/l), aluminium (Al = 0, 005mg/L), cadmium (Cd = 0.006 mg /l), chromium (Cr = 0,003 mg/l) and iron (Fe = 0, 005mg/L) and the results of water analysis of the river Opamayo the concentrations of metals are: manganese (MN = 0.120 mg/L), lead (Pb = 0,006 mg/l), zinc (Zn = 0, 333mg/L), copper (Cu = 0,005 mg/L) , aluminum (Al = 0,136 mg/L), cadmium (Cd = 0.057 mg/l), chromium (Cr = 0,150 mg/l) and iron (Fe = 0, 485mg/L), concentrations below the maximum permissible limits according to Supreme Decree D. S n ° 015-2015-MINAM (A3: Waters which can be potabilizadados with advanced treatment).

From the general assessment it is concluded that the concentration of metals in the course of the effluent of the Opamayo are lower compared to the headwaters of mines and tributaries and as it goes through the water along the basin the concentrations of metals decrease from Bido to the dilution of the highest water flows.

IV. Conclusion

The results obtained in this research of headwaters of mine were Mn with a concentration of 0.149 mg/L, Pb with 0.004 mg/L, Zn with 0.040 mg/L, Cu with 0.009 mg/l, with 0.243 mg/L, Cd with 0.012 mg/l , Cr with 0.037 mg/L and Fe with 0.371 mg/l, with a T° = 7.37 and PH = 7,69 results that are below the permissible maximum limits.

Likewise, the results of the tributaries were Mn with a concentration of 0.004 mg/L, Pb with 0.006 mg/L, Zn with 0.004 mg/L, Cu with 0.005 mg/L, Al with 0.005 mg/L, Cd with 0.006 mg/L, Cr with 0.003 mg/L and Fe with 0.005 mg/l , with a T° = 11.04 and PH = 8.53, results that are below the maximum permissible limits.

Water samples from the points of the River Opamayo has the following chemical analysis: Mn with a concentration of 0.120 mg/L, Pb with 0.006 mg/L, Zn with 0.333 mg/L, Cu with 0.005 mg/L, Al with 0.136 mg/L, Cd with 0.057 mg/l , Cr with 0.150 mg/L and Fe with 0.485 mg/l, with a T° = 9.96 and PH = 7.9, the results of the metals are below the maximum permissible limits.

The results of analysis of the water samples from the points of the Sicra River, were Mn with a concentration of 0.4 mg/L, Pb with 2.432 mg/L, Zn with 2.097 mg/L, Cu with 0.282 mg/L, Al with 0.035 mg/L, Cd with 0.002 mg/l , Cr with 0.918 mg/L and Fe with 2.152 mg/l, with a T° = 10.4 and PH = 7.5, the results of metals such as Pb with 2.432 mg/L and Cr with 0.918 mg/L are above the permissible maximum limits and the results of the following metals as : Mn with a concentration of 0.4 mg/L, Zn with 2.097 mg/L, Cu with 0.282 mg/l, with 0.035 mg/L, Cd with 0.002 mg/L and Fe with 2.152 mg/L are below the maximum permissible limits.

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