The importance of Water Quality inside Peru by accredited laboratories in ISO/IEC 17025

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Summary

The quality of purified water is important for health, wellbeing, and development of a society. To guarantee this quality, we require the analysis of water quality in a certified laboratory in ISO/IEC 17025. Here is the problem that province cities have, where they do not have certified laboratories. Therefore, the problem that has been presented is “The water quality in the distribution network of the sanitation Company from the city of Piura¨. The purpose of this research is to determine if the drinking water in the city of Piura meets the requirements to be for human consumption.

1. Introduction

Water is the most essential and fundamental for all biological activity. Water covers around 70% of the Surface from the earth. From that, 96% is salt water and only 4% remaining is sweet water.

One out of nine people in the world does not have Access to improved sources of drinkable water, and one out of three lacks of improved sanitation (United Nations-Water, 2013). These are extremely alarming figures, where it has to come into play science and politics to improve these figures for 2030.

The United Nations Organization (UNO) declared the water as a human right for the full enjoyment of life. However, around 663 millions of people do not have drinkable water, 11% of the world population (United Nations, 2015). That is why it is so important and urgent to adopt measures for that this resource increasingly scarce be accessible to all world population and to future generations.

In Peru, the challenge is to bring this resource to 4.5 million of Peruvians, mostly from rural areas. In Piura, statistics are not so different. Near 20% of the population does not have drinkable water and the population that has its doubts about the quality of it. This violates the human right every person has, which is to have good quality water access. A bad water quality has multiple implications for human health and affects the most vulnerable population that are children and older adults.

The population from Piura intuitively, knows that water quality from the distribution network from the sanitation Company is not suitable for human consumption. Therefore, the population buys filters to improve the water quality from the network or buys bottled water, and the population with fewer resources boils the water to ensure it does not contain harmful microorganisms for health.

Another difficulty the city of Piura has is the lack of supply of certified laboratories in ISO/IEC 17025. From the low supply the city of Piura has only one laboratory is regional. The others are from Lima, and they have reception office of products in Piura, making analysis costs to be very high and greater time in obtaining the results because the samples have to be sent to Lima to be analyzed. Also, the sanitation Company from the city which is the one that has the role in guaranteeing water quality in the distribution network has one laboratory. However, this one is not certified in the international regulation ISO/IEC 17025.

The Sanitation Engineering laboratory from the Hydraulics, Hydrology and Sanitation Engineering Institute from the Universidad de Piura performs this study to deliver to the competent authorities as a technical supply to apply policies and proposals to provide solution alternatives to this issue that is been demanded by the population from the city of Piura.

2. Objectives

- Verify if water quality of the distribution network from the city of Piura is suitable for human consumption.
- Verify if water quality of the distribution network from the city of Piura is the same in all the areas (north, south, east and west) where the study was performed.
- Propose to the competent authority feasible alternatives solve the issue of the population of the city of Piura.

3. Methodology

The methodology used for this water quality study has been performed by taking samples at different points in all the City of Piura (District of Castilla, Castilla and 26 de octubre), distributed in four areas of the city: the first area was the South area with three sampling points, which were called point “1 South”, point “2 South” and point “3 South”. The second area was the East of the city with three sampling points: “4 East”, “5 East” and “6 East”. The third area was the West with three sampling points: “7 West”, “8 West” and “9 West”. Finally, we sampled the North area with three points: “10 North”, “11 North” and “12 North”.

The samples taken were specific and the sampling was performed on four different days between 8 am and noon. All samples were taken from house points chosen randomly in each area chosen from the city of Piura. The field parameters such as residual chlorine, pH and electrical conductivity were analyzed at the same sampling site following a standard methodology for field parameters with measuring equipment with current maintenance and calibration, traceable to national patterns to guarantee so that the results obtained are precise and exact, besides meeting with quality controls of each parameter to make sure of the reliability of them. The other sampled parameters (Total Dissolved solids, Total Coliforms, Thermotolerant Coliforms, *Escherichia coli* and Heterotrophic Bacteria) were sampled and analyzed following a standard methodology. The parameters analyzed at the field and the ones analyzed in the laboratory were performed by trained personnel, with experience and the technical competence from the Sanitation Engineering Laboratory from the Hydraulics, Hydrology and Sanitation Engineering Institute from the Universidad de Piura.

To perform the analysis of the parameters (Total Dissolved Solids, pH, Electrical conductivity, Free Residual Chlorine, Total Coliforms, Thermotolerant Coliforms and *Escherichia coli*) established to verify water quality from the distribution network, these activities were performed by applying the ¨Standard Methods for the Examination of Water and Wastewater¨ and in a certified laboratory with a Quality Management System according to the regulation ISO/IEC 17025.

4. Location and mapping of the sampling points

Point	Reference	Coordinates		Altitude
		East	North	m.a.s.l
1 South	Santa Rosa Country Club-Castilla	17-540912	9421892	30
2 South	San Bernardo-las margaritas LI-10	17-541661	9422755	26
3 South	Av. Lloque Yupanqui 208-Castilla	17-542035	9424356	25
4 East	AA.HH Cosio del Pomar	17-546010	9427591	47
5 East	Valle la Esperanza Mz A Lt 03	17-545430	9426724	53
6 East	Parque José Abelardo Quiñones	17-541884	9426120	42
7 West	Los Titanes II etapa Mz E Lt 19	17-540506	9424981	37
8 West	San Martín-Ciro Alegría 125	17-536859	9426605	39
9 West	Urb. Piura Av. Castro Pozo 260	17-538435	9426468	47
10 North	Av. Quinta –Los Algarrobos	17-538641	9428258	49
11 North	Urb. San Felipe Mz A Lt 11	17-540663	9427240	39
12 North	Calle Don Manuel Mz A Lt 31	17-541138	9428589	37

All twelve sampled points in this study were distributed throughout the city of Piura. In the top table, the code of the point, the reference of the capturing of the simple, the exact coordinates where the sample was taken as well as the altitude of the sampled point are shown.

Also, it has been marked in a referential way in a map from the city of Piura the location of each one of the twelve sampled points in this study to visualize the distribution of the selected points for this research paper. Next, the map with the sampled points is shown.

*The points from the map are referential

The sampling was performed in two days. The first day, the three points from the South area and the three points from the East are were sampled. The second day, the six remaining points corresponding to the West and North areas from the city were sampled. In the two sampling days, the gathering of sampling was performed between 8 a.m. and 1 p.m. and with the conservation of the cold chain.

5. Results

After taking all twelve samples from the drinkable water distribution network from the four areas (North, South, East and West) from the city of Piura, and analyzed by sampling, physics-chemistry and microbiology personnel from the Sanitation Engineering Institute from the Universidad de Piura, the following results were obtained.

South Area:

Trial	Unit	L.D.M	1 South	2 South	3 South
Residual Chlorine (c)	mg Cl_2/L	------	<0.1	<0.1	0.3
Electrical conductivity (c)	µS/cm	------	901	954	270
pH(c)	Units of pH	------	8.06	7.80	7.80
Total Dissolved Solids	mg/L	3	516	547	171
Total Coliforms (NMP)	NMP/100 mL	1.1	<1.1	<1.1	1.1
Thermotolerant Coliforms (NMP)	NMP/100 mL	1.1	<1.1	<1.1	1.1
Escherichia coli	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Heterotrophic Bacteria (I)	UFC/mL	1	1	2	360

Legend: L.D.M. = Detection limit of the method
(I) Incubated to 35 ± 0,5°C/48 hours, Plate Count Agar. means
(C) In situ parameters.

East Area:

Trial	Unit	L.D.M	4 East	5 East	6 East
Residual Chlorine [c]	mg Cl_2/L	------	0.3	<0.1	0.6
Electrical conductivity [c]	µS/cm	------	1590	1735	264
pH[c]	Units of pH	------	7.70	7.50	7.46
Total Dissolved Solids	mg/L	3	979	1159	177
Total Coliforms (NMP)	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Thermotolerant Coliforms (NMP)	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Escherichia coli	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Heterotrophic Bacteria [I]	UFC/mL	1	8	1	12

Legend: L.D.M. = Detection Limit of the method.
[I] Incubated to 35 ± 0,5°C/48 hours, Plate Count Agar. Means.
[C] In situ parameters.

West Area:

Trial	Unit	L.D.M	7 West	8 West	9 West
Residual Chlorine [c]	mg Cl_2/L	------	0.6	0.6	0.6
Electrical conductivity [c]	µS/cm	------	1357	560	265
pH[c]	Units of pH	------	7.46	7.48	7.45
Total Dissolved Solids	mg/L	3	817	355	169
Total Coliforms (NMP)	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Thermotolerant Coliforms (NMP)	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Escherichia coli	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Heterotrophic Bacteria [I]	UFC/mL	1	3	9	88

Legend: L.D.M. = Detection limit of the method
[I] Incubated to 35 ± 0,5°C/48 hours, Plate Count Agar. Means.
[c] In situ parameters

North Area:

Trial	Unit	L.D.M	10 North	11 North	12 North
Residual Chlorine (c)	mg Cl_2/L	------	0.3	0.3	0.3
Electrical conductivity (c)	µS/cm	------	2130	653	1660
pH(c)	Units of pH	------	7.68	7.45	7.41
Total Dissolved Solids	mg/L	3	1371	410	1084
Total Coliforms (NMP)	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Thermotolerant Coliforms (NMP)	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Escherichia coli	NMP/100 mL	1.1	<1.1	<1.1	<1.1
Heterotrophic Bacteria (I)	UFC/mL	1	51	71	1

Legend: L.D.M. = Detection limit of the method.
(I) Incubated to ± 0,5°C/48 hours, Plate Count Agar. means.
(C) In situ parameters.

To be able to understand these values, next we will place some tables for each analyzed area of the city, indicating what parameters are meeting as set by the ¨Dirección General de Salud del Perú¨ (General Management of Health from Peru) for water for use and human consumption, besides a table with maximum permissible limits for each parameter analyzed in this study.
The following table shows the maximum allowed:

	Maximum Permissible Limit
Residual Chlorine	>0.5 mg/L
Conductivity	1500 µS/cm
pH	6.5 to 8.5
Total Dissolved Solids	1000 mg/L
Total Coliforms	<1.1 NMP/100 Ml
Thermotolerant Coliforms	<1.1 NMP/100 Ml
Escherichia coli	<1.1 NMP/100 Ml
Heterotrophic bacteria	500 UFC/mL

The following summary tables show in what points the maximum permissible limits are being met or not according to the Peruvian regulation for water for use and human consumption:

	1 South	2 South	3 South
Residual Chlorine	No	No	No
Conductivity	YES	YES	YES
pH	YES	YES	YES
Total Dissolved Solids	YES	YES	YES
Total Coliforms	YES	YES	No
Thermotolerant Coliforms	YES	YES	YES
Escherichia coli	YES	YES	YES
Heterotrophic Bacteria	YES	YES	YES

	4 Este	5 Este	6 Este
Residual Chlorine	No	No	YES
Conductivity	No	No	YES
pH	YES	YES	YES
Total Dissolved Solids	YES	No	YES
Total Coliforms	YES	YES	YES
Thermotolerant Coliforms	YES	YES	YES
Escherichia coli	YES	YES	YES
Heterotrophic Bacteria	YES	YES	YES

	7 West	8 West	9 West
Residual Chlorine	YES	YES	YES
Conductivity	YES	YES	YES
pH	YES	YES	YES
Total Dissolved Solids	YES	YES	YES
Total Coliforms	YES	YES	YES
Thermotolerant Coliforms	YES	YES	YES
Escherichia coli	YES	YES	YES
Heterotrophic Bacteria	YES	YES	YES

	10 North	11 North	12 North
Residual Chlorine	No	No	No
Conductivity	No	YES	No
pH	YES	YES	YES
Total Dissolved Solids	No	YES	No
Total Coliforms	YES	YES	YES
Thermotolerant Coliforms	YES	YES	YES
Escherichia coli	YES	YES	YES
Heterotrophic Bacteria	YES	YES	YES

6. **Conclusions**

By analyzing all the results obtained in the sampling performed in the four areas (North, South, East and West) from the distribution network of the sanitation Company from the city of Piura, we can conclude the following:

In the south area of the city, we see that it does not meet in any of the points (1 South, 2 South and 3 South) sampled the parameter of free residual chlorine. The Peruvian regulation dictates that all the water from the distribution network of drinkable water has to have minimum a concentration greater to 0.5 mg/L. This is to guarantee that the most unfavorable user (the most distant) has an antibacterial effect, and the water they get is free of harmful pathogen microorganisms for the health of people. Also, we see that in the south area also unfavorable results were obtained in the total coliforms parameter (3 South). This is extremely alarming because these microorganisms may cause a lot of harm to the population that consumes this water.
The other parameters (pH, Electrical conductivity, Total Dissolved Solids, Thermotolerant Coliforms, Escherichia coli and heterotrophic bacteria) at all sampled points does meet with the Peruvian regulation for water for use and human consumption.

At the East area of the city, two of the three points (4 East and 5 East) sampled do not meet the Peruvian regulation of Free Residual Chlorine. Here, as in the South area, the

distribution network users do not have the guarantee that the water they receive is free of pathogen microorganisms. Despite that, the results of bacteria and coliforms show there is none of these organisms, stays the uncertainty this water might have them during the day because the samples performed were specific and were not performed during the whole to see if the water presents these organisms.
Another parameter that does not meet with the Peruvian regulation is the Electrical Conductivity, which exceeds the maximum permissible limit which is 1500 µS/cm. Curiously, this parameter does not meet in the same two points tan the free residual chlorine parameter. Although there is no relationship between the two parameters, the population is this area may have potential problems in the future because the accumulation of dissolved salts that may cause kidney stones problems.
Finally, point 5 East does not meet with the Total Dissolved Solids parameter, which exceeds the Maximum Permissible Limit of 1000 mg/L. This parameter does have a relationship with the Electrical Conductivity and reaffirms that the water from these points has a lot of dissolved salts.

The results from the west area of the city meet with all the parameters established in this research paper. Here, we may say that the water that gets the users from the distribution network of drinkable water is of quality for the day and hour sampled. To say more precisely that the water that the water is of quality in this area, we would have to increase the points of sampling to twelve and the frequency every two hours, besides doing it during the four seasons of the year so that to be certain that the water from this area is of quality.

Finally, we see at the north area of the city that the results for the Free Residual Chlorine parameter do not meet for any of the sampled points (10 North, 11 North and 12 North). Here, like in the south area of the city, users do not have a guarantee that the water they receive is free of pathogen microorganisms, which puts them in a high-risk situation.
The Electrical Conductivity and Total Dissolved Solids parameters that are closely related to a number of salts dissolved in the water do not meet in the same points, which are 10 North and 12 North. This may bring in the long run health problems related to kidney stones to the user of the distribution network.
The microbiological parameters from this area do meet the Peruvian regulation. However, there is a risk that users are not free from this risk because the Free Residual Chlorine from this area at no point meets the regulation.

In general terms, after analyzing the results obtained from this study, we can conclude that the drinkable water from the distribution network from the sanitation Company from the city of Piura is not suitable for human consumption. This is because it does not meet, in many parameters, the Maximum Permissible Limits that requires the Peruvian regulation for human consumption water. This is a very concerning situation because the city of Piura is one of the most important cities of Peru.

7. Recommendations

After making the conclusions from the results obtained, we are going to make some recommendations to improve the water quality from the distribution network from the sanitation Company from the city of Piura. All these recommendations are performed based on the results obtained in this paper, and taking into account only the parameters taken into account as indicators of water quality to determine of it is suitable for human consumption or not in the city of Piura.

For this paper, only eight parameters have been considered, which I consider the most critical ones from the Peruvian regulation to determine or not the water quality. The Peruvian regulation takes into account 22 parameters among microbiological, biologicals and physical-chemical to determine the water quality for use and human consumption.

All the recommendations carried out in this paper are with the purpose of improving the water quality from the distribution network so that contribute to the improvement of the quality of living of the inhabitant from the city of Piura.

The sustainable management of the water, water infrastructure and Access to a safe supply, trustworthy and accessible of water and adequate sanitation services improve the level of life, expand local economies and promote the creation of more decent job positions and a more social inclusion. The sustainable water management is also an essential powerful reason for the Green growth and sustainable development (United Nations, 2016).

1. As we see in the results, in eight of the twelve sampled points the Free Residual Chlorine parameter is not met. In some, there were concentrations way under the minimum, and in others, there was no concentration. Probably this is because a bad chlorine dosage in the distribution network or because the lack of a number of dosage stations making not arriving at the farthest points of the city the minimum required concentration by the Peruvian regulation. It is recommended to a study to analyze if the dosage and the number of dosage stations are correct to guarantee the minimum concentration required to the furthest user.

2. Another of the parameters that do not meet in several sampled points are the Electrical Conductivity and the Total Dissolved Solids, which are related to the dissolved salts in water. The dissolved salts in the water are very stable, therefore are very hard to eliminate by the conventional methods for treating purified water. To eliminate them, it is required reverse osmosis, which is an expensive technology. Most likely, the source that the sanitation company uses to supply its drinkable water treatment plant is from underground, which has a lot of salts. It is recommended to the sanitation Company to change the source of underwater water that supplies the treatment plant to a surface water source to guarantee values under the Maximum Permissible Limits by the Peruvian regulation.

3. From the twelve samples from the four microbiological parameters analyzed, only at “3 South” point, the Maximum Permissible Limit was not met. This is related to the lack of effective chlorine dosage of the water in the distribution network at the south area of the city. Here, like in the first recommendation, the sanitation Company must perform a study to determine the correct chlorine dosage to ensure that the water is free of pathogen microorganisms.

4. For a better analysis and to take better decisions to improve water quality from the distribution network from the sanitation Company from the city of Piura, we recommend expanding the sampling areas, the points to simple, as well as the frequency of the samples. That is, dividing each area (North, South, East and West) in a quadrant (four areas) and in each new area take twelve samples during the whole day, every two hours, repeating this in each season of the year (summer, fall, winter and spring). This would be making 48 samples at the north area, 48 samples at the south area, 48 samples at the east area and 48 samples at the west area. This would be repeated in each season of the year making a total of 768 samples to be analyzed and be able to make a more detailed analysis of the water quality from the distribution network from the sanitation Company from the city of Piura. This would allow comparing how water quality varies in the city during the whole day and the year. With the results obtained from these analyses, we could obtain many conclusions of water quality from the city, and be able to take specific actions for improvement such as regional or national policies to improve the parameters where the maximum permissible parameters from the Peruvian regulation are not met.

5. Finally, we recommend the sanitation Company to seek financing from international organizations through research projects to be able to perform the 768 samplings and to have greater information of the water quality that is given by the distribution network of the city. It is calculated that the average cost for each sample is around $200 US dollars, making a total of all 768 samples and analysis of $153,600 US dollars.

8. Bibliography

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