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PROBABLE EFFECTS OF WASTEWATER FROM THE CITY OF CAJAMARCA ON THE WATER-SOIL-PLANT SYSTEM OF THE HAMLETS OF LA VICTORIA, YANAMARCA AND LA COLLPA

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ABSTRACT

The research was carried out to determine the probable concentrations of heavy metals and coliforms, in the water-soil-plant system of the Rye Grass crop, caused by the wastewater of the city of Cajamarca to the water bodies in the hamlets of La Victoria, Yanamarca and La Collpa, physical analyses were carried out, (pH, Electrical conductivity, Total solids, Temperature, Turbidity), chemical (Copper, Chromium, Aluminum, Zinc, Iron, Nitrates, Sulfates, Nitrites), Microbiological (Total and thermotolerant coliforms). In the soil system, phosphorus, potassium, organic matter, aluminum and texture analyses were carried out, in the plant system total and thermotolerant coliforms were analyzed, in the water bodies system physical, chemical and biological analyses were carried out, physical parameters of the water evaluated give us results located within the maximum permissible limits established for the country; the chemical results of the water indicate that concentrations of: Iron, Copper and nitrites exceed the LMP, with concentrations of: 2.6 mg/l, in the soil system the results obtained from P, K, MO were above the average levels for the Cajamarca valley, the microbiological results of the concentrations of total and thermotolerant coliforms exceeded the LMP at all the points sampled both in the bodies of water and plants.

KEYWORDS: Wastewater, Water quality, Huacariz Canal, Yanamarca-Rumicucho Canal, La Victoria, La Collpa Canal, Rye Grass.

1. INTRODUCTION

The population located in the southern part of the city of Cajamarca uses wastewater, but is not aware of the degree of contamination that it causes in its soils, bodies of water and cultivated and uncultivated plant species, especially those used as fodder for cattle feed. However, it is known that color intensity is not a reliable indicator of its quality (Lenntech 2006). It is therefore necessary to initiate research that evidences the impact of the wastewater generated in the city of Cajamarca, on the water-soil-plant system in the hamlets of La Victoria, Yanamarca and La Collpa.

The WHO (1989) reports that the average daily consumption of water is 50 L/person. If the average consumption per person is multiplied by the population of Cajamarca, we would have to consume 14,400,000 L of water daily. Of this total, 75% (10,800,000 L.) is evacuated to the sewers and piped to the oxidation lagoons; and then the continuous contamination of the water-soil-plant system of the hamlets of La Victoria, Yanamarca and La Colpa, however, in its course, most of it is used directly for the irrigation of pastures (Rye gras x clover), without having received any treatment. The problem of water pollution is even more accentuated if one considers that in the city of Cajamarca there are companies that provide various services, among these, the collectors of fresh milk such as Gloria and Incalac, tanneries, bakeries, mines, brick factories, restaurants and hotels, among others, which evacuate their sewage directly into the rivers.

Wastewater contains nutrients for plant development, its use for crop irrigation is common because it contributes positively to yield (Campos 2011). However, it is likely that diseases related to intestinal parasites and faecal bacteria that are indirectly or directly in contact with them are transmitted to consumers and farmers, nowadays the presence of volatile organic compounds (VOCs) in wastewater collection and treatment systems is of great importance. and toxic volatile organic compounds (VOCs), hydrogen sulfide to the atmosphere (Metcaf & Eddy 1995).

The General Objective was to determine the probable effects of wastewater from the city of Cajamarca on the water-soil-plant system of the hamlets of La Victoria, Yanamarca and La Collpa. And as Specific Objectives : a) To quantify the probable concentrations of pollutants of the wastewater generated in the city of Cajamarca in the irrigation water, used in the hamlets of La Victoria, Yanamarca and La Collpa b) To quantify the probable concentrations of contaminant of the wastewater generated in the city of Cajamarca in the soil (rhizosphere), of the hamlets of La Victoria, Yanamarca and La Collpa, c) To quantify the probable concentrations of contaminant in the wastewater generated in the city of Cajamarca in the Rye grass plant (Lolium multiflorun L.), used as fodder in the hamlets of La Victoria, Yanamarca and La Collpa. As a General Hypothesis: The levels of physical, chemical and biological factors of the water-soil-plant system of the hamlets of La Victoria, Yanamarca and La Colpa, correspond to the contents of the wastewater of the city of Cajamarca and probably have severe effects on the plants, animals and consumers of these.

2. THEORETICAL FRAMEWORK

Water is one of the natural resources that is part of the development of any country; It is the most abundant chemical compound on the planet and is essential for the development of life. Their availability is gradually less due to their contamination by various means, including aquifers, which represents an environmental, economic and social imbalance (Esponda 2001).

Taking into account that, by definition, quality is the expression of a set of characteristics of a good or service to meet the satisfaction of a user or consumer (Orozco 2009).

The natural state of water can be affected by natural processes, for example, soils, rocks, insects and animal excrement, the other way that its natural state can be changed, is artificially, by human participation, by substances that change pH, salinity and this is achieved through human and mining activities; others dispose of their garbage in the beds of rivers and streams. Another reason is the excessive use of fertilizers, which are dragged by the waters into the rivers where the algae grow in excess, preventing the entry of light into the lake or lagoon and causing the death of aquatic fauna. Another form of contamination is the presence of heavy metals such as lead and cadmium, which generate bioaccumulation, and finally, urban waste or sewage containing excrement (La Peña 1999).

Wastewater is defined as water of varied composition from discharges from municipal, industrial, commercial, service, agricultural, livestock, domestic uses, including fractionations and in general, from any other use, as well as the mixture of them (Rodríguez and Durán 2006).

The WHO (2006) and FAO (2011) promote the use of domestic wastewater (RA) in agriculture, but recognize the risks it poses to health and the environment (Pescod 1992, Kiziloglu et al. 2008, Segal et al. 2011, Cirelli et al. 2012). Therefore, the reuse of treated wastewater (ART) for agricultural irrigation becomes a technical solution to minimize soil degradation and restore soil nutrient content (Kiziloglu et al. 2008).

Additionally, Segal et al. (2011) indicate that the reuse of ART for irrigation of agricultural crops increases the susceptibility of crops to osmotic stress and increases the potential for groundwater contamination. When crops are irrigated with ART, the first and main changes are found in the salinity and sodicity parameters of the soil (Marques et al. 2009).

The main objective of the treatment of RA should be the elimination of pathogenic organisms León (1995), WHO (2006), such as those related to excreta (Escherichia coli bacteria, Vibro chorelae, Salmonella spp., Shigella spp.), helminths (Ascaris, Ancylostoma, Necator, Hymenolepis, Strongyloides, Toxocara, Trichuris, Taenia spp.), flukes, protozoa, viruses, those related to vector-borne pathogens, skin irritations, and chemicals. With regard to the criteria of physical-chemical quality of water for irrigation, the FAO guidelines (1999) propose salinity and alkalinization of soils as parameters.

In this vein, the reuse of ART may require a change in the plant species used for cultivation, modification of fertilizer doses, remodeling of the irrigation system, adoption of precautions to protect agricultural workers and the health of consumers (Mujeriego 1990).

Medeiros et al. (2005), found that ART, with sand filters, improves soil characteristics, such as pH, percentage of organic matter (M.O.), potassium (K), calcium (Ca) and magnesium (Mg), but increases salinity problems, evaluated yields of corn crop irrigated with ART and irrigation water; no significant difference in yields was found. but it indicates that irrigation with AR can save the use of fertilizers. Kiziloglu et al. (2008), evaluated improvements in soil fertility without affecting soil and plant quality when applying irrigation with ART. The results indicate that irrigation with ART significantly affects the chemical properties of the soil in the first 30 cm of depth and the nutrient content in the plants after harvest.

Müller (2010), an expert at the German Federal Energy Office (OFEN) and head of the Suisse Energie programme , argues that a house can be heated by recovering heat from used water through a technology that has been available for 20 years. This innovative form of heating will be used in the Olympic city of Vancouver, Canada. The principle is simple: take the heat from the water in the pipeline that is at a temperature ranging from 12°C to 20°C, and use it to turn the heating pumps. With them, wastewater can reach between 65°C and 70°C.

According to the results obtained by Díaz (1992), in raw wastewater due to its sanitary origin, nitrogen was mostly presented as N–NH4+, probably from human urea and nitrogenous organic compounds.

Table 1: Typical Domestic Wastewater Composition.

Componente	Concentración, mg/litro
Carbonato	2,4
Bicarbonato	45,0
Cloruro	3,5
Sulfato	5,8
Nitrato	1,1
Fosfato	0,0
Sodio	0,5
Potasio	0,8
Calcio	10,4
Magnesio	9,8
Sílice	5,8
Fluoruro	0,8
Manganeso	0,0
Hierro	0,0
Aluminio	0,1
Boro	0,1
Sólidos disueltos totales	63,8
Alcalinidad total	39,0

Fuente: Universidad Rey Juan Carlos

Table 2: Average Composition of Household Sewage Fluid (in Grams per Person per Day).

Sólidos	Total	Mineral	Orgánico
Totales	250	105	145
Disueltos	160	80	80
Suspendidos	90	25	65
Sedimentables	54	15	39
No sedimentables	36	10	26

Fuente: Universidad Rey Juan Carlos.

2.1. Total Phosphorus

Phosphorus is essential for the growth of organisms and can be a nutrient that limits primary productivity. In high concentrations due to the incorporation of wastewater or treated water, it stimulates the accelerated growth of macro and microorganisms, causing eutrophication (Díaz 1992).

Research by Díaz (1992), with respect to the sampling carried out in the dry season, indicates that the concentration of total phosphorus in the sample that entered the system was 0.9 mg/L, of which 3.13 % is removed in the first wetland (0.87 mg/L). In the case of the second wetland, the total phosphorus concentration increases to 0.9 mg/L. At the end of the system, there was a total removal of 21.87 % (0.7 mg/L). In the rainy season, the concentration of total phosphorus presented a concentration of 1.96 mg/L before entering the system and 40.35 % was removed at the end of treatment. The results show higher values in the rainy season and with greater variability as it passes through the different modules of the system.

2.2. Water Quality Parameters

2.2.1. Physical Parameters

A. pH: Its measurement reflects variations in the quality of the water source. In crops, the pH of the water in contact with the roots can affect plant growth in two main ways, Outside this range, root absorption is hindered and if the deviation in pH values is extreme, it can deteriorate the plant or present toxicity due to the excessive absorption of phytotoxic elements. With soil pH and irrigation water close to or above 7.5, the correct assimilability of nutrients such as phosphorus, iron, manganese, zinc, copper is affected. At pH close to or below 7.5, the assimilation of calcium, magnesium, and molybdenum may be affected (Dupchak 2005).

B. Temperature: Quantities that measure the state of matter. When a piece of matter (body) exchanges heat with the environment, it usually changes its temperature. Temperature causes sensations of heat and cold, increases and decreases the size of bodies (e.g., mercury in thermometers), and emits radiation from bodies. The temperature in natural groundwater varies only slightly in its annual average, while in surface waters it fluctuates according to the seasons of the year (CEPIS 2004).

C. Conductivity: It is defined as the ability of inorganic salts in solution (electrolytes) to conduct electric current. In most aqueous solutions, the greater the amount of dissolved salts, the greater the conductivity, this effect continues until the solution is so full of ions that freedom of movement is restricted and the conductivity can decrease instead of increasing, in cases of two different concentrations with the same conductivity. The harder it is (presence of calcium and magnesium carbonates), the greater the conductivity of the water (WHO 1990).

D. Turbidity: It is the presence of particles due to insufficient treatment or as a result of the suspension of a foreign material (clays, organic and inorganic matter and some microorganisms), in the distribution system (Carranza 2001).

E. Flow: It is the measurement of the flow of water that passes through the cross-section of a conduit (river, stream, channel) of water, it is known as gauging or flow measurement. This flow rate depends directly on the area of the cross-section to the stream and the average water velocity (CEPIS 2004).

Table 3: Important Contaminants in Waste Water.

Contaminantes	Motivo de su importancia
Sólidos Suspendidos	Los sólidos suspendidos pueden llevar al desarrollo de depósitos de barro y condiciones anaerobias, cuando los residuos no tratados son volcados en el ambiente acuático
Materia orgánica biodegradable	Compuesta principalmente de proteínas, carbohidratos y grasas, por lo general, se mide en términos de DBO y DQO. Si es descargada sin tratamiento al medio ambiente, su estabilización biológica puede llevar al consumo del Oxígeno natural y al desarrollo de condiciones sépticas.
Microorganismos patógenos	Los organismos patógenos existentes en las aguas residuales pueden transmitir enfermedades.
Nutrientes	Tanto el Nitrógeno como el Fósforo, junto con el Carbono, son nutrientes esenciales para el crecimiento. Cuando son lanzados en el ambiente acuático, pueden llevar al crecimiento de la vida acuática indeseable. Cuando son lanzados en cantidades excesiva en el suelo, pueden contaminar también el agua subterránea.
Contaminantes importantes	Compuestos orgánicos en inorgánicos seleccionados en función de su conocimiento o sospecha de carcinogenicidad, mutanogenicidad, teratogenicidad o elevada toxicidad. Muchos de estos compuestos se encuentran en las aguas residuales.
Materia orgánica refractaria	Esta materia orgánica tiende a resistir los métodos convencionales de tratamiento de aguas residuales. Ejemplos típicos incluyen detergentes, pesticidas agrícolas, etc.
Metales pesados	Los metales pesados son normalmente adicionados a los residuos de actividades comerciales e industriales, debiendo ser removidos si se va a usar nuevamente el agua residual.
Sólidos inorgánicos disueltos	Componentes inorgánicos como el calcio, sodio y sulfato son adicionados a los sistemas domésticos de abastecimiento de agua, debiendo ser removidos si se va a reutilizar el agua residual.

Fuente: Mara (1976)

2.2.2. Biological Parameters

These are data that are used to identify each of the values, by means of a numerical value and this is indicative to evaluate or assess a certain situation such as physical, chemical and biological (Carranza 2001).

a. Thermotolerant and Total Coliforms. - The generic name coliforms designates a group of bacterial species that have certain biochemical characteristics in common and relevant importance as indicators of water and food contamination. Coliforms are a family of bacteria that are commonly found in plants, soil, and animals, including humans. Due to its wide diversity, the coliform group has been divided into two groups: total coliforms and fecal coliforms. fecal coliforms, those of intestinal origin (WHO 1990).

Table 4: Biological Parameters (values in N.M.P./100 ml).

Parámetro Biológicos	Unidad	Vegetales de tallo bajo	Vegetales de tallo alto
		Valor	Valor
Coliformes Termotolerantes	NMP/100ml	1000(3)	2000(3)
Coliformes Totales	NMP/100ml	5000(3)	5000(3)
Vibrión Cholerae		Ausente	Ausente
Escherichia Coli	NMP/100ml	100	100
Enterococos	NMP/100ml	20(5)	100
Salmonella Sp.		Ausente	Ausente
Helmintos	huevos/litro	<1(8)	<1(1)

Fuentes: 1, 3, 5, 8.

(1) Calidad del Agua en la Agricultura -Rev. 1 - Estudio FAO "Riego y Drenaje 29"

(3) Norma Técnica Nacional de la República de Honduras- 2001

(5) Seoanez Calvo Mariano (1995). Ingeniería del Medio Ambiente - Criterios Generales de Calidad para Aguas de uso Agrario. Estado de Ontario – Canadá.

(8) Organización Mundial de la Salud – OMS.

Table 5: Effects Caused by Contaminants Present in Wastewater.

Contaminantes	Parámetro de caracterización	Tipo de efluentes	Consecuencias
Sólidos suspendidos	Sólidos suspendidos totales	* Domésticos * Industriales	* Problema estéticos * Depósitos de barros * Adsorción de contaminantes * Protección de patógenos
Sólidos flotantes	Aceites y grasas	* Domésticos * Industriales	* Problemas estéticos
Materia orgánica biodegradable	DBO	* Domésticos	* Consumo de oxigeno
		* Industriales	* Mortalidad de peces * Condiciones sépticas
Patógenos	Coliformes	* Domésticos	* Enfermedades transmitidas por el agua
Nutrientes	Nitrógeno	* Domésticos	* Crecimiento excesivo de algas (eutrofización del cuerpo receptor)
	Fósforo	* Industriales	* Toxicidad para los peces (amonio) * Enfermedades en niños(nitratos) * Contaminación del agua subterránea.
Compuestos no biodegradables	Pesticidas Detergentes Otros	* Industriales * Agrícolas	* Toxicidad (varios) * Espumas (detergentes) * Reducción de la transferencia de oxigeno (detergentes) * No biodegradabilidad * Malos olores
Metales pesados	Elementos específicos (As, Cd, Cr. Cu, Hg, Ni, Pb, Zn.)	* Industriales	* Toxicidad * Inhibición al tratamiento biológico de las aguas residuales * Problemas con la disposición de los barros en la agricultura * Contaminación del agua subterránea

Fuente: Campos (1994)

2.2.3. Heavy metals

Among the metals to be identified we have

Copper: Copper is an essential metal for organisms, but when it exceeds certain concentrations, it can produce toxic effects, mainly gastrointestinal and liver disorders. There are suggestions that copper levels above 0.6 mg/L may result in liver damage in dairy cows. Copper deficiency in plants is detected in acidic organic soils, in soils derived from very acidic igneous rocks and in leached soils of coarse texture, this element is essential for humans, it is estimated that 2 mg. is the need for copper for an adult person (Thornton 1993).

Iron: It is an essential micro element for plants, it is part of cytochromes, proteins and participates in the oxidation-reduction reaction in the plant. In the leaves, almost all iron is found in the chloroplasts, where it plays an important role in the synthesis of chloroplastic proteins. Iron can be deposited as hydroxide and clog the gills of organisms, decreasing their respiratory potential. For trout with water pH values of 6.5 to 7.5 and concentrations of 0.9 mg/l of iron, it is fatal (Lenntech 1998).

Chromium: This element can be found in water in both hexavalent and trivalent states, although in rare form it can appear in drinking water, chromium values are less than 0.05 mg/L. Non-essential, it has no physiological function in plants.

Cr^{6+} affects growth and reduces plant productivity. Cr^{3+} is not easy, absorbed by the roots, 90% stays in the roots. It can be reduced with SO_2 to Cr^{3+} or removed by anion exchange. Their presence may be associated with discharges of industrial wastes and are usually found in surface waters (CEPIS 2004).

Aluminium: Aluminum toxicity limits plant growth in strongly acidic soils by reducing the depth of the roots, making them short and brittle, the lateral parts thickening and acquiring a brown coloration. Roots affected by Al are inefficient in absorbing water and nutrients. Aluminum interferes with the absorption, transportation, and use of several essential elements including Cu, Zn, Ca, Mg, Mn, K, P, and Fe.

When the pH is below 5.5 there is an antagonism between Ca and Al because aluminum affects calcium uptake in plants producing frizz or curling of young leaves and collapse of growth tips or petioles. Aluminium also causes morphological damage to some plant organs (Lenntech 1998).

Zinc: It is an essential micro element that serves as an enzymatic cofactor, with many functions, since Zn must be essential for the activity, regulation and stabilization of the protein structure. Zn is found in soils and rocks in the divalent form Zn^{2+}. The soluble Zn content increases with decreasing pH and vice versa. The first symptoms of Zn deficiency observed in the field are reduced leaf size. Depending on the crop, the disorder is called the white bud (in corn and sorghum), speckled leaf or frenching (citrus) and the falcada leaf (cocoa). Other symptoms are chlorosis and stunting of plants; also the leaves of the new shoots show yellow to whitish bands on the underside of the leaves (Cornejo 1993).

2.2.4. Non-Metals

Sulfates: Sulfates (SO_4^{-2}) after bicarbonates, are the main anions present in water; which can occur naturally or as a result of industrial water discharges and the use of agricultural fertilizers. When sulfates occur naturally, it is possible that their origin is due to some natural deposit of minerals or by atmospheric deposition (Castro 2009).

Nitrates: Nitrates are considered to be the end product of the oxidation of nitrogenous materials. The amount of nitrates in surface water are generally less than 5 ppm as NO_3 and have no adverse effects for ordinary uses. The consequences associated with this deterioration can have an impact on the health of communities in the short, medium or long term, hence the need to take measures to reduce pollution by them, Pérez (1984).

Nitrites: The presence of nitrites in the water is indicative of recent fecal contamination (Catalán 1971). In general, the concentration of nitrites in surface water is very low, but it can occasionally appear at unexpectedly high concentrations due to industrial and domestic wastewater contamination (Albert 1990).

3. METHODOLOGY

3.1. Location of the Study Area

The area where the research work was carried out is located in the districts of Cajamarca, Llacanora and Jesús, between 2,718 and 2,650 meters above sea level.

In the coordinates UTM, 0774929–E, 9210160-N and 781772-E and 9203181-N, of the city of Cajamarca, it mainly involves the hydrographic basin of the Cajamarca River.

The variables to be evaluated were The water quality indicators are represented by physical parameters (pH, temperature, turbidity, total dissolved solids, electrical conductivity and flow), chemical (sulfates, nitrites, nitrates and heavy metals, especially aluminum, iron, copper, chromium and zinc), and biological (total coliforms and thermotolerant coliforms).

Table 6: Wastewater Monitoring Stations.

Código de campo	Origen de la fuente	Punto de muestreo	Localidad	Distrito	Departamento	Altitud msnm.	UTM		Observaciones
							Este	Norte	
BCH - 1	Rio Mashcón	Bocatoma	Cajamarca	Cajamarca	Cajamarca	2,718	774929	9210160	Naciente Canal Huacariz
PO - 2	Canal Huacariz	Deb. Posas de oxidación	Cajamarca	Cajamarca	Cajamarca	2694	777260	9208031	Francisco Sánchez Murga
BCRY-1	Rio Chonta	Bocatoma	Baños del Inca	Cajamarca	Cajamarca	2671	779885	9206828	Naciente Canal Yamarca - Rumicucho.
BCLC-1	Rio San Lucas Mashcón	Bocatoma	Cajamarca	Cajamarca	Cajamarca	2,705	774920	9210120	Puente a baños del Inca
PCV-4	Canal Yanamarca Rumicucho	La Victoria	Cajamarca	Cajamarca	Cajamarca	2665	780298	9204576	Fundo UNC - Puente
CY-5	Canal Yanamarca Rumicucho	Yanamarca	Cajamarca	Cajamarca	Cajamarca	2661	782875	9202995	Compuerta Metal - Felipe Murillo
CLC-2	Canal La Collpa	Collpa	Cajamarca	Cajamarca	Cajamarca	2660	782968	9201448	Catalino Misahuamán Canto
PF-1	Pozo subter	Deb. Posas de oxidación	Cajamarca	Cajamarca	Cajamarca	2693	777259	9208029	Francisco Sánchez Murga
PES-1	Manantial El Sauce	Deb. Posas de oxidación	Cajamarca	Cajamarca	Cajamarca	2694	777445	9208011	Javier Valdivia Huayac
MI-1	Manantial Ingapila	Iscoconga	La Collpa-Jesús	Llacanora	Cajamarca	2650	781772	9203181	Santos Mantilla Huamán

Source: Own Elaboration.

Note: BCH-1: Bocatoma canal Huacariz. PO: Point below the oxidation pools. BCRY-1: Rumicucho-Yanamarca canal intake. BCLC-1: Boca takes La Collpa channel. PCV-4: La Victoria Canal Point – UNC. CY-5: Yanamarca Canal. CLC-2: Canal la Collpa. PF-1: Francisco underground well. PES-1: El Sauce Point Spring. MI: Ingapila spring.

Table 8: Soil and Pasture Monitoring Stations.

Código de campo	Origen de la fuente	Punto de muestreo	Localidad	Distrito	Departamento	Altitud msnm.	UTM		Observaciones
							Este	Norte	
PO - 2	Canal Huacariz	Deb. Posas de oxidación	Cajamarca	Cajamarca	Cajamarca	2694	777260	9208031	Francisco Sánchez Murga
PCV-4	Canal Yanamarca Rumicucho	La Victoria	Cajamarca	Cajamarca	Cajamarca	2665	780298	9204576	Fundo UNC - Puente
CY-5	Canal Yanamarca Rumicucho	Yanamarca	Cajamarca	Cajamarca	Cajamarca	2661	782875	9202995	Compuerta Metal - Felipe Murillo
CLC-2	Canal La Collpa	Collpa	Cajamarca	Cajamarca	Cajamarca	2660	782968	9201448	Catalino Misahuamán Canto
PES-1	Manantial El Sauce	Deb. Posas de oxidación	Cajamarca	Cajamarca	Cajamarca	2694	777445	9208011	Javier Valdivia Huayac

Fuente: Elaboración propia.

4. RESULTS AND DISCUSSION

4.1. Physical-Chemical Analysis of Irrigation Water.

These measures indicate around which value the data are grouped, generating representative values of the respective measurements.

4.1.1. pH

This variable indicates that the pH has a mean of 8.016, a standard deviation of 0.487 pH, a variance of 0.237 pH², and a coefficient of variability of 6.07%, the minimum pH recorded is 7.300 with a Q1 (first quartile, 25%) of 7.58, indicating that 25% of the data are equal to or less than 7.58, with a median of 7.90

pH, a Q3 (quartile 3) of 8.550, indicating that 75% of the data are equal to or less than 8.550, a maximum pH of 8.630 pH, with a range of 1.330, with a mode and mode of 0, with an asymmetry of -0.02 and a kurtosis of -1.68. Dupchak 2005.

He states that pH can affect the availability of nutrients, so that the root apparatus can absorb the different nutrients, these must obviously be dissolved.

Extreme pH values can cause the precipitation of certain nutrients so that they remain in a form not available to plants, also D.S. 002-2008 – MINAN, give pH values, between 6.5 to 8.5 for the use of category III water, for irrigation and drinking of animals.

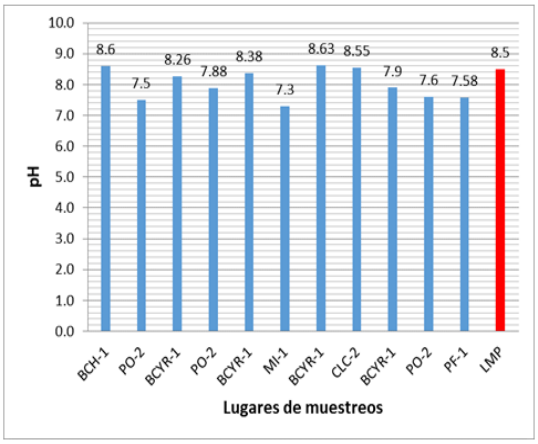

Gráfico 1. **Concentración del pH en los diferentes puntos de monitoreo de aguas residuales.**

4.1.2. Electrical Conductivity (uS/cm)

This variable indicates that the electrical conductivity has a mean of 604.2, (uS/cm), a standard deviation of 319.5, a variance of 102104.4, and a coefficient of variability of 52.89, the minimum electrical conductivity recorded is 235 with a Q1 (first quartile, 25%), indicating that 25% of the data are equal to or less than 354.0, with a median of 495.0, a Q3 (quartile 3); of 881.0, indicating that 75% of the data are equal to or less than 881.0, a maximum electrical conductivity of 1170.0, with a range of 935.0, with a mode and mode of 0, with an asymmetry of 0.68 and a kurtosis of -0.91.

The WHO 1990, In most aqueous solutions, the greater the amount of dissolved salts, the greater the conductivity, this effect continues until the solution is so full of ions that freedom of movement is restricted and shows that conductivity can decrease instead of increase, giving cases of two different concentrations with the same conductivity. The harder it is (presence of calcium and magnesium carbonates), the greater the conductivity of the water, in addition to the D.S. 002-2008 – MINAN, give conductivity values < 2000 uS/cm, for the use of category III water, these levels being below the LMP, in the different monitoring points.

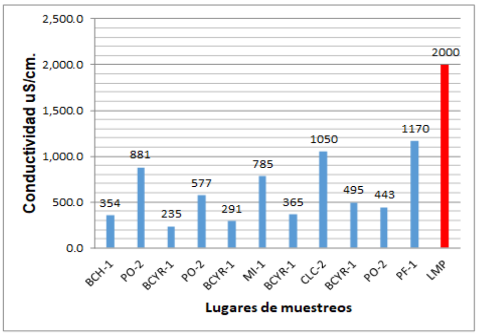

Gráfico 2. **Concentración de la conductividad eléctrica en los diferentes puntos de monitoreo.**

4.1.3. Total Dissolved Solids (mg/L)

This variable indicates that the total dissolved solids, has a mean of 298.5, a standard deviation of 163.5, a variance of 26738.0, and a coefficient of variability of 54.78, the minimum total dissolved solids recorded of 112.7 with a Q1 (first quartile, 25%) of 170.2, indicating that 25% of the data are equal to or less than 170.2, with a median of 238.0, a Q3 (Quartile 3), of 481.0, indicating that 75% of the data are equal to or less than 481, a maximum of total dissolved solids of 576.0, with a range of 463.3, with a mode and mode of 0, with an asymmetry of 0.65 and a kurtosis of -1.16.

DWTP, 2001, Suspended solids can lead to the development of sludge deposits and anaerobic conditions when untreated wastewater is discharged into the aquatic environment. The results indicate that it is within the LMP.

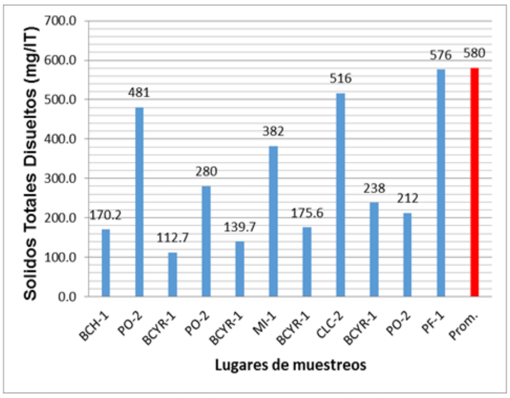

Gráfico 3. **Concentración de solidos totales disueltos en los diferentes puntos de monitoreo.**

4.1.4. Aluminium (mg/l)

This variable indicates that aluminum has, mean, 0.2153 mg/l, a standard deviation of 0.2095, a variance of 0.0439, and a coefficient of variability of 97.35, a minimum recorded aluminum presence of 0.0310, with a Q1 (first quartile, 25%) of 0.0800, indicating that 25% of the data are equal to or less than 0.0950, with a median of 0.0950, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 0.2630, a maximum presence of aluminum of 0.6510, with a range of 0.6200, with a mode of 0.095, a mode of 2, with an asymmetry of 1.45 and a kurtosis of 0.98.

In Lenntech magazine 1998, he states that aluminum toxicity limits plant growth in strongly acidic soils by reducing root depth, and interferes with the absorption, transport, and use of several essential elements including Cu, Zn, Ca, Mg, Mn, K, P, and Fe. It affects the absorption of calcium in plants by producing frizz or curling of young leaves and also causes morphological damage to some plant organs.

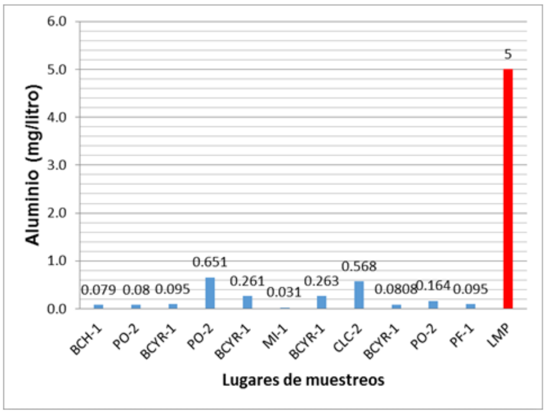

Gráfico 5. **Concentración de aluminio en los diferentes puntos de monitoreo.**

4.1.5. Iron Fe (mg/l)

This variable indicates that it has, a mean of 0.615, a standard deviation of 0.692, a variance of 0.479, and a coefficient of variability of 112.43, a minimum recorded iron presence of 0.221, with a Q1 (first quartile, 25%) of 0.238, indicating that 25% of the data are equal to or less than 0.238, with a median of 0.348, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 0.750, a maximum iron presence of 2.600, with a range of 2.379, with a mode of 0.348, a mode of 2, with an asymmetry of 2.79 and a kurtosis of 8.33.

Lenntech magazine 1998 states that iron in aquatic environments is not harmful as it is in low content, but it is usually harmful in the presence of high concentrations. For trout with water pH values of 6.5 to 7.5 and concentrations of 0.9 mg/l of iron, it is fatal.

D.S. 002-2008 – MINAN, give iron values in irrigation waters of 1 mg/l, with values found at the T1 monitoring point (BCH), above the LMP, while at the remaining monitoring points they are below the LMP.

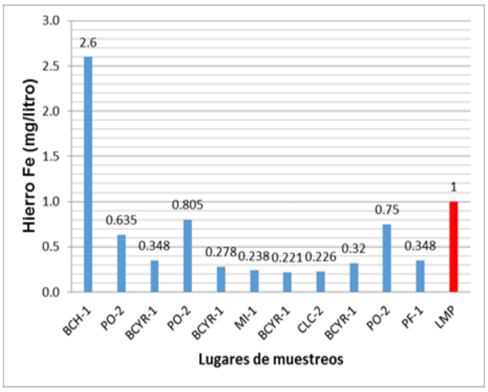

Gráfico 6. **Concentración del hierro en los diferentes puntos de monitoreo.**

4.1.6. Copper Cu (mg/l)

The variable indicates that this metal has, mean, 0.2727, a standard deviation of 0.2494, a variance of 0.0622, and a variability coefficient of 91.46, a minimum recorded copper presence of 0.0130, with a Q1 (first quartile, 25%) of 0.1060, indicating that 25% of the data are equal to or less than 0.1060, with a median of 0.1740, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 0.5870, a maximum copper presence of 0.7350, with a range of 0.7220, with a mode of 0.194, a mode of 2, with an asymmetry of 1.09 and a kurtosis of -0.47.

Thornton 1993 states that this metal can produce toxic effects, mainly gastrointestinal and liver disorders. There are suggestions that copper levels above 0.6 mg/L may result in liver damage in dairy cows.

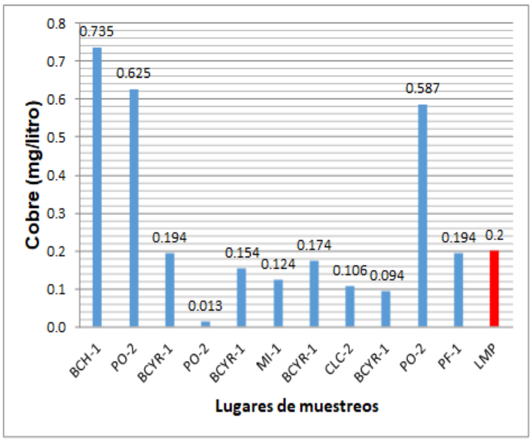

Gráfico 7. **Concentración del cobre en los diferentes puntos de monitoreo.**

4.1.7. Chromium Cr6 (mg/l)

This variable indicates that chromium has a mean of 0.03164, a standard deviation of 0.02672, a variance of 0.00071, and a coefficient of variability of 84.47, a minimum recorded chromium presence of 0.00200, with a Q1 (first quartile, 25%) of 0.01900, indicating that 25% of the data are equal to or less than 0.01900, with a median of 0.02200, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 0.02900, a maximum chromium presence of 0.09100, with a range of 0.08900, with a mode of 0.022, a mode of 3, with an asymmetry of 1.62 and a kurtosis of 1.91.

CEPIS 2004 states that its presence of chromium may be associated with discharges of industrial wastes and is generally found in surface waters, which indicates that there is the presence of chromium at all monitoring points and it is due to industrial discharges, taking into account that the LMP is 0.1 mg/L.

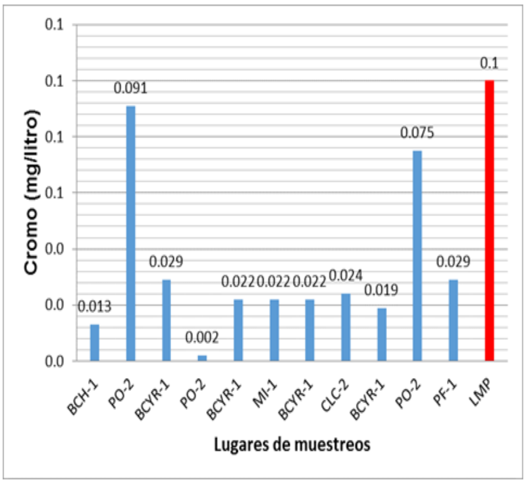

Gráfico 8. **Concentración del cromo en los diferentes puntos de monitoreo.**

4.1.8. Zinc (mg/l)

In the following variable it indicates that it has a mean of 0.6852, a standard deviation of 0.2813, a variance of 0.0791, and a coefficient of variability of 41.05, a minimum recorded zinc presence of 0.0550, with a Q1 (first quartile, 25%) of 0.4230, indicating that 25% of the data are equal to or less than 0.4230, with a median of 0.7800, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 0.9000, a maximum zinc presence of 1.0390, with a range of 0.9840, with a mode of 0.78, a mode of 2, with an asymmetry of -1.20 and a kurtosis of 1.34.

Cornejo 1993 states that the first symptoms of Zn deficiency observed in crops are reduction in leaf size, chlorosis and stunting of plants; Also the leaves of the new shoots show yellow to whitish bands on the underside of the leaves.

The EPA recommends that the water should not contain more than 5 ppm of zinc, also the LMP is 2 mg/L, for D.S. 002-2008 – MINAN, they give values for Zinc in irrigation waters of 2 mg/l. results indicate that this element is below the LMP.

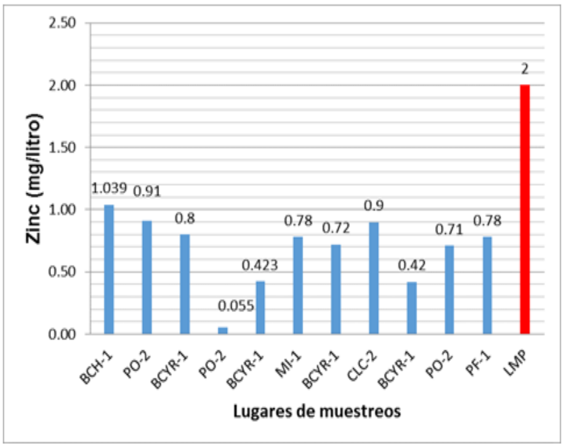

Gráfico 9. **Concentración del zinc, en los diferentes puntos de monitoreo.**

4.2. Nitrites NO2 (mg/l)

This variable indicates that it has a mean of 0.04837, a standard deviation of 0.02811, a variance of 0.00079, a coefficient of variability of 58.11, a minimum recorded nitrite presence of 0.00250, with a Q1 (first quartile, 25%) of 0.02200, indicating that 25% of the data are equal to or less than 0.02200, with a median of 0.05400, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 0.06670, a maximum of 0.10050 nitrites, a range of 0.09800, with a mode of 0.0667, a mode of 2, with an asymmetry of 0.08 and a kurtosis of -0.22.

The presence of nitrites in water is indicative of recent fecal contamination (Catalán L. et al., 1971, Metcalf and Eddy 1998), it should also be noted that nitrite is in an intermediate state of oxidation between ammonia and nitrate, in general the concentration of nitrites in surface water is very low, but it can occasionally appear in unexpectedly high concentrations due to industrial and domestic wastewater pollution (Albert, 1990).

4.2.1. NO3 Nitrates (mg/l)

In the following variable it indicates that it has a mean of 6.56, a standard deviation of 7.48, a variance of 56.01, a coefficient of variability of 114.13, a minimum presence of nitrates recorded of 0.70, with a Q1 (first quartile, 25%) of 1.23, indicating that 25% of the data are equal to or less than 1.23, with a median of 2.25, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 16.20, a maximum of nitrates of 18.40, a range of 17.70, with a mode of 18.40, a mode of 2, with an asymmetry of 0.96 and a kurtosis of -1.07.

Pérez (1984). Nitrate is one of the most interesting forms of nitrogen in natural, wastewater and treated wastewater, it generally occurs at trace level in surface water, but can reach high levels in groundwater.

Nitrate is found only in small amounts in domestic wastewater, but in the diluent of denitrifying biological treatment plants, nitrate can be found in concentrations of up to 30 mg of nitrate as N/L.

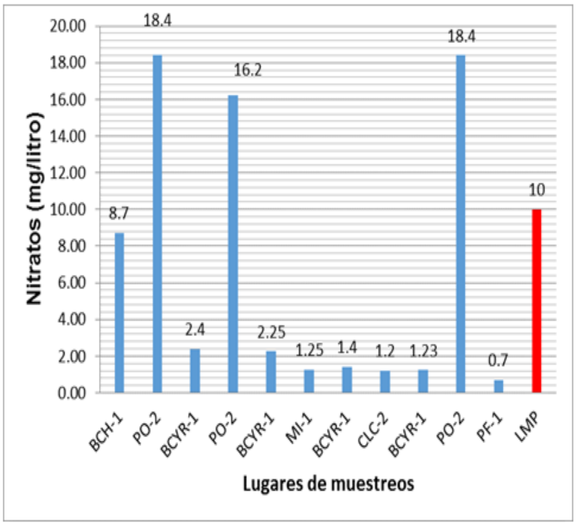

Gráfico 11. **Concentración de nitratos en los puntos de monitoreo**.

4.2.2. SO4 Sulfates (mg/l)

This variable indicates that it has a mean of 36.54 mg/l, a standard deviation of 16.55, a variance of 273.80, a coefficient of variability of 45.29, a minimum presence of sulfates recorded of 16.00, with a Q1 (first quartile, 25%) of 22.00, indicating that 25% of the data are equal to or less than 22.00, with a median of 38.00, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 54.40, a maximum of sulfates of 56.40, a range of 40.40, with a mode of 2256.40, a mode of 2, with an asymmetry of 0.10 and a kurtosis of -1.96.

Castro 2009 states that sulfates can occur naturally or as a result of discharges from industrial waters and the use of agricultural fertilizers. When sulfates occur naturally, it is possible that their origin is due to some natural deposit of minerals or by atmospheric deposition, Andrenc 2011, states that sulfates are found in natural waters in a wide range of concentrations. Mine water and industrial effluents contain large amounts of sulfates. Results found that the levels of this element are below the LMP.

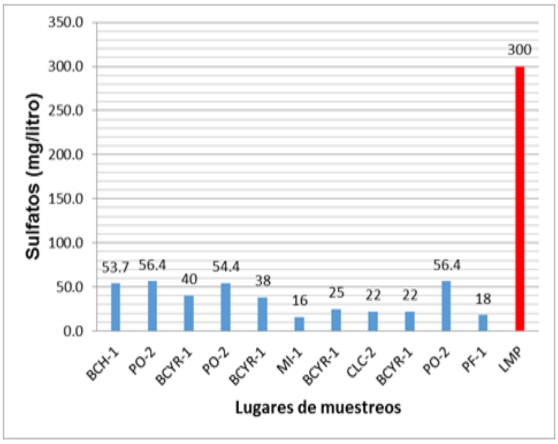

Gráfico 12. Concentración de sulfatos en los puntos de monitoreo.

4.2.3. Caudal (l/s)

In this variable it indicates that it has a mean of 69.50, a standard deviation of 39.70, a variance of 1574.70, and a coefficient of variability of 57.13, a minimum recorded flow of 1.00, with a Q1 (first quartile, 25%) of 40.0, indicating that 25% of the data are equal to or less than 40.0, with a median of 80.0, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 80.0, a maximum flow of 120.0, with a range of 119.0, with a mode of 80.0, a mode of 6, with an asymmetry of -0.73 and a kurtosis of -0.07.

This parameter has no significance in terms of the amount of water resources since wastewater has been constantly contaminating the existing bodies of water in the villages where the research is carried out.

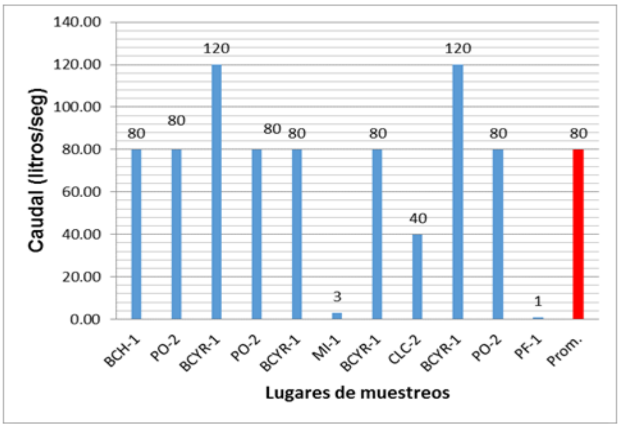

Gráfico 13. **Caudal en los puntos de monitoreo**.

4.2.4. Temperature (°C)

This variable indicates a mean of 17.05, a standard deviation of 2.154, a variance of 4.640, and a coefficient of variability of 11.79, a minimum recorded temperature of 15.60, with a Q1 (first quartile, 25%) of 16.025, indicating that 25% of the data are equal to or less than 16.025, with a median of

18.150, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 20,450, a maximum temperature of 21,300, with a range of 5,700, with a mode and mode of 0, with an asymmetry of 0.15 and a kurtosis of -1.33.

DWTP, 2001, The temperature of wastewater is usually always higher than that of supply water, mainly due to the incorporation of hot water from houses and different industrial uses, which affects both biological activity and the amount of gases dissolved in the wastewater.

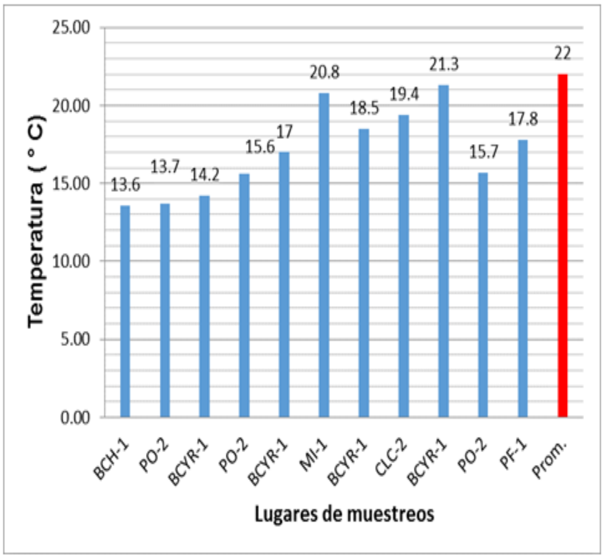

Gráfico 14. **Concentración de la temperatura en los puntos de monitoreo.**

4.3. Soil Analysis.

4.3.1 Phosphorus P (ppm)

This variable indicates, a mean of 50.60, a standard deviation of 12.24, a variance of 149.78, and a coefficient of variability of 24.19, a minimum amount of phosphorus recorded of 32.25, with a Q1 (first quartile, 25%) of 37.45, indicating that 25% of the data are equal to or less than 37.45, with a median of 53.56, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 58.34, a maximum amount of phosphorus of 66.91, with a range of 34.66, with a mode of 0, a mode of 0, an asymmetry of -0.27 and a kurtosis of -1.08.

DWTP, 2001, Organic phosphorus is of little importance in most domestic waste, but it can be an important constituent in industrial and agricultural discharges, detergents and sludge from domestic wastewater, causing eutrophication in water bodies.

Velásquez 2014 states that phosphorus for the Cajamarca valley in normal soils varies from 2 to 10 ppm in normal soils, finding very high values for the Cajamarca valley in soils irrigated with wastewater.

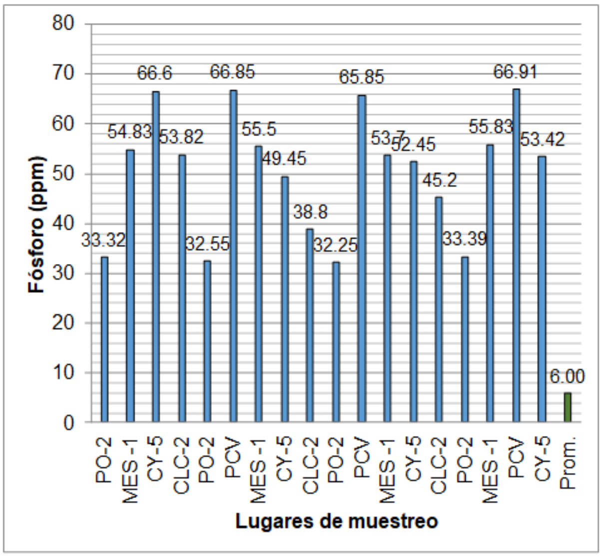

Gráfico 15. **Fósforo en los suelos de los diferentes puntos de monitoreo.**

4.3.2. Potassium K (ppm)

This variable indicates, a mean of 341.89, a standard deviation of 21.87, a variance of 478.34, and a coefficient of variability of 6.40, a minimum amount of potassium recorded of 305.00, with a Q1 (first quartile, 25%) of 320.25, indicating that 25% of the data are equal to or less than 320.25, with a median of 350.00, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 360.50, a maximum amount of potassium of 370.00, with a range of 65.00, a mode of 315, 350, 360, 365, the mode of 2, with an asymmetry of -0.39 and a kurtosis of -1.47.

Velásquez 2014 states that potassium varies from 250 to 380 ppm in the Cajamarca valley, in normal soils, with K contents above the averages for the Cajamarca valley, whose soils are irrigated with wastewater.

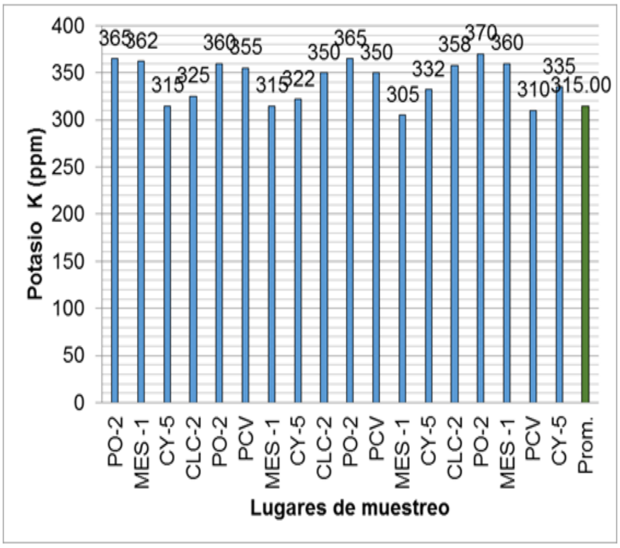

Gráfico 16. **Potasio en los suelos de los diferentes**

4.3.3 pH

This variable indicates that there is a mean of 7.278, a standard deviation of 0.441, a variance of 0.194, and a coefficient of variability of 6.06, the minimum pH recorded is 6.200 with a Q1 (first quartile, 25%) of 7.200, indicating that 25% of the data are equal to or less than 7.200, with a median of 7.375, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 7.60, a maximum pH of 7.800, with a range of 1.60, a mode of 7.20, a mode of 4, with an asymmetry of -1.31 and a kurtosis of 1.36.

Velásquez, 2014, states that the pH for the soils of the Cajamarca valley varies from 5.8 to 8.0, ranging from moderately acidic to moderately alkaline, in the research it was found levels that exceeded the average for the Cajamarca valley.

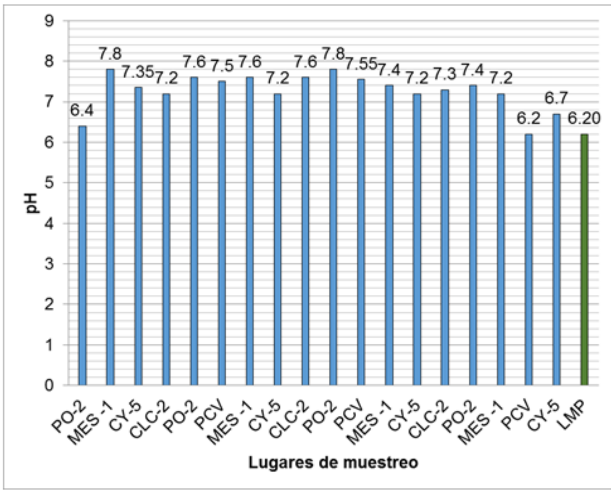

Gráfico 17. **Concentración de pH en los suelos de los diferentes puntos de monitoreo**.

This variable indicates that it has a mean of 8.818, a standard deviation of 4.176, a variance of 17.436, and a coefficient of variability of 47.35, the minimum organic matter recorded is 3.800, with a Q1 (first quartile, 25%) of 5.050, indicating that 25% of the data are equal to or less than 5.050, with a median of 7.650, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 12,750, a maximum organic matter of 15,600, with a range of 11,800, with a mode of 0, a mode of 0, and with an asymmetry of 0.29 and a kurtosis of -1.64.

ETAP, 2001, They are solids that come from the animal and plant kingdoms, as well as from human activities related to the synthesis of organic compounds.

Velásquez, 2014, states that Organic Matter varies from 2.50 to 5.00 % in normal soils, with high values found in soils irrigated with wastewater in the Cajamarca Valley.

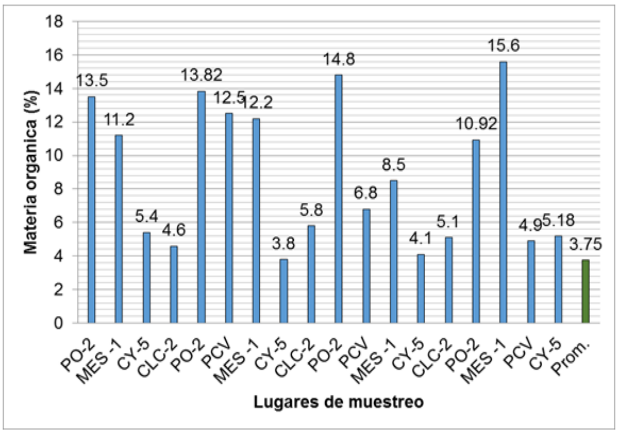

Gráfico 18. **Contenido de materia orgánica en los diferentes puntos de monitoreo.**

4.3.5. Aluminium (mg/l)

This variable indicates, a mean of 0.000, a standard deviation of 0.000, a variance of 0.0000, and a coefficient of variability of 0.000, a minimum recorded aluminum presence of 0.000, with a Q1 (first quartile, 25%) of 0.000, indicating that 25% of the data are equal to or less than 0.00, with a median of 0.000, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 0.000, a maximum presence of aluminum of 0.000, with a range of 0.000, with a mode of 0.000, a mode of 18, with an asymmetry of 0.000 and a kurtosis of 0.000.

The existence of Al in treated water comes from the common use of aluminum salts in coagulation of treated water for domestic consumption, (http://www4.ujaen.es/~mjayora/docencia_archivos/Chemical%20analytical%20environmental/tema%2010.pdf), treated water. During the investigation, no aluminum values were found.

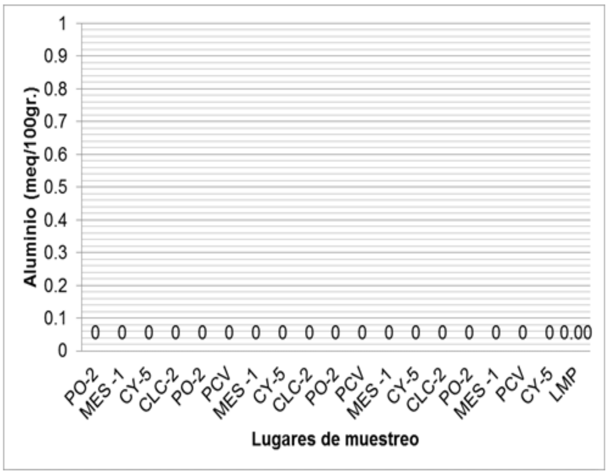

Gráfico 19. **Contenido de aluminio de los suelos en los diferentes puntos de monitoreo**.

4.3.6 Sand (%)

This variable indicates that it has a mean of 44.06, a standard deviation of 7.47 a variance of 55.82, and a coefficient of variability of 16.96, a minimum amount of sand recorded is 29.00, with a Q1 (first quartile, 25%) of 40.50, indicating that 25% of the data are equal to or less than 40.50, with a median of 45.00, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 49.00, a maximum amount of sand of 55.00, with a range of 26.00, with a mode of 45, a mode of 4, an asymmetry of -0.58 and a kurtosis of -0.29. indicating that the soils are loam to clay.

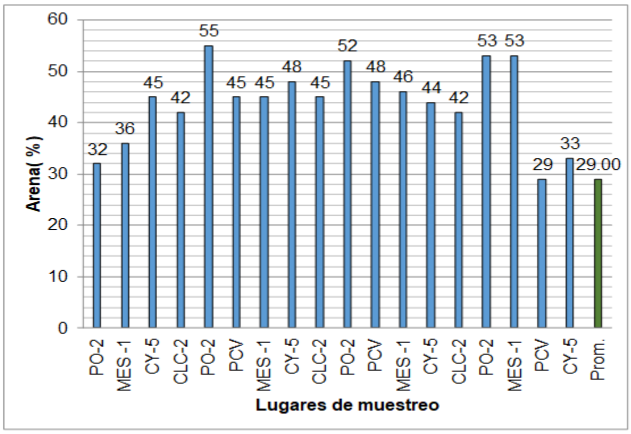

Gráfico 20. **Porcentaje de arena en el suelo de los diferentes puntos de monitoreo**

4.3.7. Slime (%)

This variable indicates that it has a mean of 27.667, a standard deviation of 3.515, a variance of 12.353, and a coefficient of variability of 12.70, a minimum amount of silt recorded is 18.00, with a Q1 (first quartile, 25%) of 26.00, indicating that 25% of the data are equal to or less than 26.00, with a median of 28.00, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 30.500, a maximum amount of sand of 33.00, with a range of 15.00, with a mode of 28, a mode of 5, an asymmetry of -0.84 and a kurtosis of 2.30. the soils are found with a high silt content.

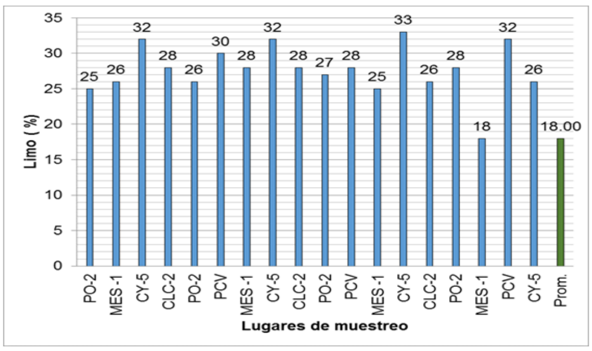

Gráfico 21. **Porcentaje de limo en el suelo de los puntos de monitoreo**

4.3.8. Clay (%)

This variable indicates that it has a mean of 24.39, a standard deviation of 6.45, a variance of 41.66, and a coefficient of variability of 26.47, a minimum amount of clay recorded is 18.00, with a Q1 (first quartile, 25%) of 19.00, indicating that 25% of the data are equal to or less than 19.00, with a median of 22.50, a Q3 (quartile 3), indicating that 75% of the data are equal to or less than 26.25, a maximum amount of sand of 41.00, with a range of 23.00, with a mode of 19, a mode of 4, an asymmetry of 1.69 and a kurtosis of 2.54. the percentage of clay was above the average for the Cajamarca valley.

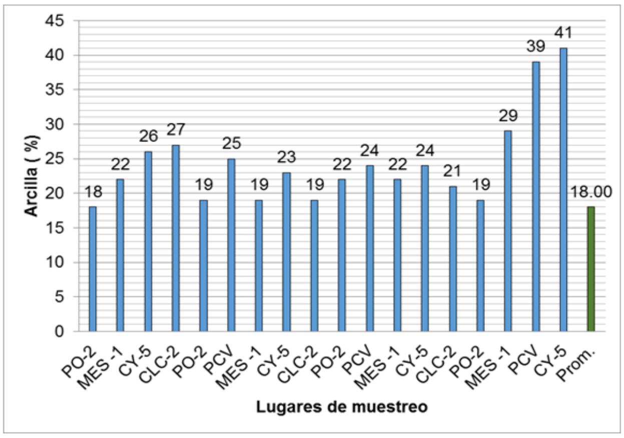

Gráfico 22. **Porcentaje de arcilla en los suelos de los diferentes puntos de monitoreo.**

Table 9: Soil Monitoring Locations.

Punto de Monitoreo	Código de laboratorio	Característica
PO-2	SU0240-EEBI-12	T1
MES -1	SU0244-EEBI-12	T2
CY-5	SU0250-EEBI-12	T3
CLC-2	SU0252-EEBI-12	T4
PO-2	SU0280-EEBI-13	T5
PCV	SU0282-EEBI-13	T6
MES -1	SU0284-EEBI-13	T7
CY-5	SU0292-EEBI-13	T8
CLC-2	SU0296-EEBI-13	T9
PO-2	SU0360-EEBI-13	T10
PCV	SU0361-EEBI-13	T11
MES -1	SU0368-EEBI-13	T12
CY-5	SU0366-EEBI-13	T13
CLC-2	SU0364-EEBI-13	T14
PO-2	SU0631-EEBI-14	T15
MES -1	SU0634-EEBI-14	T16
PCV	SU0633-EEBI-14	T17
CY-5	SU0632-EEBI-14	T18

Fuente: Elaboración propia 2014.

4.4. Analysis of Total Coliforms in irrigation waters.

This variable indicates that at all the monitored points of the different irrigation canals, the LMP in total coliforms exceeds 5000 NMP/ml., as reported by PAHO/CEPIS/96, for category III waters.

4.5. Analysis of thermotolerant coliforms in irrigation water.

This variable indicates that at all the monitored points of the different irrigation canals, the LMP in thermotolerant coliforms of 1000 NMP/ml, reported by PAHO/CEPIS/96, for category III waters, is exceeded.

4.6. Plant Analysis (Rye Grass).

This variable indicates that at all the monitored points for Rye Grass plants irrigated with irrigation water mixed with wastewater, they exceed the LMP in total coliforms, for short-stemmed plants of 5000 NMP/ml. And for thermotolerant coliforms for short-stemmed plants of 1000 NMP/100 ml. released by the NTNRH, and the WHO, according to the results of the analyses obtained in the DESA-Cajamarca Laboratory, there are total and thermotolerant coliforms that exceed the LMP. (NTNH: National Technical Standard of the Republic of Honduras-2001).

Table 10: Microbiological Analysis of Bodies of Water, Contaminated with Wastewater.

P. MUESTREO	ENSAYOS		ENSAYOS		ENSAYOS		ENSAYOS		ENSAYOS		ENSAYOS	
	C. TOTALES	C. TERMO TOLERANTES	C. TOTALES	C. TERMO-TOLERANTES	C. TOTALES	C. TERMO TOLERANTES	C. TOTALES	C. TERMO TOLERANTES	C. TOTALES	C. TERMO TOLERANTES	C. TOTALES	C. TERMO TOLERANTES
	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)	(NMP/100 ml)
BCH-1	$2.7X10^3$	$2.2X10^3$	$9.4 X 10^4$	$9.4 X 10^4$	$1.4X10^5$	$4.9 X 10^3$	$1.4X10^5$	$4.9 X 10^3$	$7.9X10^4$	$4.0 X 10^3$	$2.7 X 10^3$	$2.2 X 10^3$
PO-2	$> 1.6X10^5$	$2.5X10^3$	$1.6X10^6$	$3.5 X 10^5$	$9.2X10^5$	$2.8 X 10^4$	$9.2X10^5$	$2.8 X 10^4$	$3.5X10^5$	$4.9 X 10^4$	$> 1.6X10^5$	$2.5X10^3$
BCYR-1	$> 1.6X10^5$	$3.5X10^4$	$1.6X10^5$	$4.1 X 10^3$	$1.6X10^6$	$1.7 X 10^4$	$1.6X10^6$	$1.7 X 10^4$	$2.1X10^5$	$9.4 X 10^4$	$> 1.6X10^5$	$3.5X10^4$
PCV-4	$> 1.6X10^5$	$2.5X10^4$	$1.6X10^6$	$4.7 X 10^4$	$9.2X10^6$	$3.5 X 10^4$	$9.2X10^6$	$3.5 X 10^4$	$2.2X10^6$	$7.9 X 10^4$		
CY-5	$1.3X10^5$	$3.4X10^3$	$2.7X10^6$	$3.9 X 10^3$	$3.3X10^4$	$2.1 X 10^3$	$3.3X10^4$	$2.1 X 10^3$	$1.3X10^5$	$3.4 X 10^3$		
MI-1	168**	4**			120**	3**	120**	3**	168**	4**		
CLC-2			$1.3X10^5$	$3.4 X 10^3$	$1.3X10^5$	$3.4 X 10^3$	$1.3X10^5$	$3.4 X 10^3$				
PF-1					$7.9X10^5$	$4.9 X 10^4$	$7.9X10^5$	$4.9 X 10^4$				
BCLC-1					$9.4X10^5$	$2.3 X 10^4$	$9.4X10^5$	$2.3 X 10^4$	$4.7X10^4$	$2.7 X 10^3$		
MES									$3.3X10^4$	$4.0 X 10^3$		
BCLC-2									$3.5X10^5$	$7.0 X 10^4$		

Fuente: Elaboración propia 2014.

5. CONCLUSION

In the water bodies, the physical analyses of pH, electrical conductivity, STD, flow and temperature were carried out.

- pH. The indicators were: 7.30 T2 and 8.63 T5, (MI-1, BCYR-1), being within the LMP which is 6.5 - 8.5, according to D.S. 002-2008-MINAM for category III waters. Watering vegetables and animal drinking.
- The results of the electrical conductivity are 235 T3 and 1170 T11 (BCYR-1, PF-1) uS/cm, this variable did not exceed the LMP which is <2000, according to D.S. 002-2008-MINAM, for category III waters. Watering vegetables and animal drinking.
- STD. These were 112.7, Q3 June and 576 T11 (BCYR-1, PF-1) February.
- Turbidity was determined between 73 T7 and 435 T1 (BCYR-1, BCH-1) UNT in the sampled sites.
- Flow rates were determined between 40 T8, and 120 T3 (CLC-2, BCYR-1), l/s.
- The temperature was recorded between 13.6 and 21.3 °C. T9 (BCYR-1)
- In Chemicals, the results of: Aluminum, Iron, Copper, Chromium, Zinc, Sulfates, Nitrates and Nitrites are described below:
- Aluminum. The results obtained were a minimum value of 0.031 mg/l, T6 (MI), a maximum value of 0.651 mg/l T4 (PO-2), not exceeding the LMP, for irrigation waters, which is 5 mg/l. according to D.S. 002-2008-MINAM for category III waters. Watering vegetables and animal drinking.

- Iron. Minimum values of 0.221 mg/l T7 (BCYR-1), a maximum of 2.6 mg/l T1 (BCH-1) were obtained, the latter exceeding the LMP values of 1 mg/l. according to D.S. 002-2008-MINAM for category III waters. Watering vegetables and animal drinking.
- Copper. The minimum result of this indicator was given in T1, 0.735 mg/l (BCH-1), T2, 0.625 mg/l (PO-2) and T10 0.587 (PO-2), exceeding the LMP of 0.2, with the minimum value being 0.013 mg/l (BCH-1), a maximum value of 0.735 mg/l (BCH-1). according to D.S. 002-2008-MINAM for category III waters. Watering vegetables and animal drinking.
- Chrome. The presence of this metal in wastewater does not exceed the LMP, which is 0.1 mg/l, for irrigation water, having minimum values of 0.002 mg/l (PO-2) T4 and a maximum of 0.091 mg/L (PO-2). T2, according to D.S. 002-2008-MINAM for category III waters. Watering vegetables and animal drinking.
- Zinc. This element had an almost homogeneous behavior, with minimum values of 0.055 mg/l T4 (PO-2) and a maximum value of 1.039 mg/l T1 (BCH-1), not exceeding the LMP of 2 mg/l. according to D.S. 002-2008-MINAM for category III waters. Watering vegetables and animal drinking.
- SO4 sulfates. The presence of this indicator did not have a major impact on irrigation water because results were obtained below the LMP of 300 mg/l. according to D.S. 002-2008-MINAM, for category III waters. Watering vegetables and animal drinking.
- Nitrites NO2. This variable had a homogeneous behavior, exceeding the LMP of 0.06 mg/l, with values of 0.1005 mg/l T1, 0.0667mg/l T2, 0.0639 mg/l T3, 0.0628 mg/l T4 and 0.0667 mg/l T10 (PO-2). according to D.S. 002-2008-MINAM for category III waters. Watering vegetables and animal drinking.
- NO3 nitrates. This variable has exceeded the LMP of 10 mg/l, according to D.S. 002-2008-MINAM for category III waters. Irrigation of vegetables and animal drinking, with the values of 18.4 mg/l T2, 16.2 mg/l T4 and 18.4 mg/l T10 (PO-2).

In the Springs: PF-1, MES-1 and MI-1, the results obtained in the physical analyses were

- pH. These are found within the LMPs. (7.3 and 7.58)
- Electrical conductivity, this parameter did not exceed the LMP which is < of 2000, being between 725 uS/cm. (MI) and 1170 uS/cm. (PF-1).
- STD. These are between the 382 mg/l (MI-1) and 576 mg/l (PF-1) ranges
- Turbidity, between 0.45 UNT (PF-1) and 192 UNT point (MI-1) were found.
- Flow rates, flow rates between 1 l/s (PF-1) and 3 l/s (MI-1) were determined.
- The temperature was recorded between 17.8°C (PF-1) and 21.8°C. (MI-1)

Microbiological analysis: This analysis was carried out in the three canals that carry water for irrigation purposes to the hamlets of La Victoria, Yanamarca and La Colpa, whose waters are captured from the rivers: Mashcón and Chonta, through the canals: Huacariz, Yanamarca Rumicucho and La Collpa, and springs, whose results indicate that the content of these exceeds the LMP, > 1000 and > 5000 for total and thermotolerant coliforms, according to the FAO "Irrigation and Drainage 29" and National Technical Standard of the Republic of Honduras – 2011, WHO, whose pathogens have been affecting the health of the population of the identified villages, also affect short-stemmed plants compromising the animals that feed on them. This effect is more noticeable in the summer months (May and June), when their properties are irrigated with untreated wastewater, also in the springs results were obtained for total coliforms of 3.3 x 104 to 9x105 NMP/100 ml (PF-1), and 4. X103 to 4.9 x 104 MPN/100 mL in Thermotolerant Coliforms for MI-1.

5.1. Concentrations to Soils

From the results of the soil analyses, **the following conclusion was reached**

Phosphorus P. This variable in soils irrigated with wastewater has high amounts that exceed those obtained in lands not irrigated with wastewater, the average for the Cajamarca valley being 32.25 ppm. Minimum values of 32.25 ppm T10 (PO-2) and 66.91 ppm T17 (PCV) were obtained

Potassium K. In soils irrigated with wastewater it has high amounts that exceed those obtained in lands not irrigated with wastewater, the average for the Cajamarca valley being 305 ppm. Minimum values of 305 ppm T12 (MES-1) and 370 ppm T15 (PCV) were obtained

pH. In soils irrigated with sewage, the pH. Minimum values of 6.20 T17 (PCV) and 7.80 T2 and T10 (MES-1 AND PO-2) were obtained.

Organic matter. In soils irrigated with wastewater, there are high amounts of organic matter that exceed those obtained in lands not irrigated with wastewater, the average for the Cajamarca valley being 3.8%. Minimum values of 3.8 % T8 (CY-5) and 15.60% T15 (PO-2) were obtained.

Aluminum Al. In soils irrigated with sewage, aluminum was not found available to plants.

Sand %. In the soils of the Cajamarca valley they have values of 29 to 55 %, sand, in T17 (PCV) and T5 (PO-2).

Slime %. The average is 18 to 33%, in T16 (PCV) and T13 (CRY-5).

Clay %. The average varies from 18 to 41 %, in T1 (PO-2) and T18 (CYR-5) being clay loam to sandy clay loam.

Average data on the nutrient content in the soils the results are as follows: In the valley of Cajamarca the following can be said: Phosphorus: varies from 2 to 10 ppm (from very low to medium), Potassium varies from 250 to 380 ppm (from medium to high), Organic matter from 2.50 to 5.00 % (from medium to high), Nitrogen varies from 0.12 to 0.23 % (from medium to high), pH from 5.8 to 8.0 (Moderately acidic to moderately alkaline), There is no presence of aluminum due to the pH, in the valley of Cajamarca the production is of Rye grass + clover, for grazing cattle hence the high content of organic matter, (data provided by Eng. Tulio Velásquez Camacho, Head of INIAA-Cajamarca soil laboratories).

5.2. Concentrations to Plants

From the results obtained from the samples of grasses (Rye Grass): PO-2, PCV-4, MES-1, CY-5 and CLC-2, it was determined that total and thermotolerant coliforms have exceeded LMPs of >1000 and > 5000 for short-stemmed plants. According to the FAO "Irrigation and Drainage 29" and National Technical Standard of the Republic of Honduras – 2011, WHO.

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