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Calidad del agua residual no entubada vertida por dos parques industriales en la ciudad de Puebla, México

Quality of not piped wastewater discharged by two industrial parks in the city of Puebla, Mexico

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Resumen

En el estado de Puebla, México se tienen registradas 215140 unidades económicas según el Censo Económico 2009 realizado por el Instituto Nacional de Estadística y Geografía (INEGI), de estas 174 son grandes empresas, 1196 medianas, 5652 pequeñas y 208118 micro empresas, en su mayoría se encuentran ubicadas en los trece parques industriales (PI) de la ciudad, con diversos giros como: textil, metal mecánica, química, embotelladoras, alimentarias, farmacéuticas, etc. Algunas industrias y comunidades descargan sus aguas residuales en forma directa con escaso o nulo tratamiento hacia los cuerpos receptores entre ellos los ríos Atoyac, Alseseca y algunas barrancas. Los avances tecnológicos e industriales generados a partir de la segunda mitad del siglo XIX han redundado en múltiples beneficios para los seres humanos, convenientes a las necesidades personales. Sin embargo, estos hechos han crecido junto con un fenómeno cuyo impacto es evidentemente negativo para la subsistencia de la vida en todo el planeta: la contaminación o deterioro del aire, agua, suelo y planta del ambiente debido a la presencia o aumento exagerado de sustancias que perjudican la salud. La evidente contaminación que presentan las aguas residuales no entubadas, generan un importante riesgo para la salud de los habitantes de zonas residenciales cercanas, debido a esta problemática el objetivo de este trabajo de investigación consistió en determinar la calidad del agua de diez efluentes industriales aledaños a los PI 5 de mayo y Puebla 2000, que desembocan a los ríos Atoyac y Alseseca y que posteriormente se almacenan en la presa Manuel Ávila Camacho para que finalmente el agua sea distribuida mediante el canal principal de riego y canales secundarios hacia el Distrito de Riego 030 “Valsequillo” para la irrigación de cultivos agrícolas. La importancia del estudio de la calidad fisicoquímica y microbiológica del agua se debe a su influencia en el suelo y en los productos cosechados, además de los impactos negativos en la salud humana que trae consigo emplear agua contaminada para riego. Se realizaron los análisis mediante la implementación de las metodologías descritas en las Normas Oficiales Mexicanas NMX-Materia de agua. Se determinaron *in situ* los parámetros: T°C, conductividad eléctrica, materia flotante, pH y oxígeno disuelto; en el laboratorio: dureza total, cloruros, grasas y aceites, sodio, sulfatos y demanda bioquímica de oxígeno, coliformes fecales, etc. Las concentraciones obtenidas se compararon con los límites máximos permisibles que establecen las Normas Oficiales Mexicanas NOM-001-SEMARNAT-1996 y la NOM-003-SEMARNAT-1997.

Palabras clave: Parques industriales, agua no entubada, barrancas, calidad de agua.

Abstract

In the state of Puebla, Mexico have been registered 215140 economic units according to the Economic Census 2009 conducted by the National Institute of Statistics and Geography (INEGI), of these 174 are large enterprises, 1196 medium, 5652 small and 208118 micro enterprises, as most are located in thirteen industrial parks (IPs) of the city, with various twists as textile, metalworking, chemical, bottling, food, pharmaceutical, etc.. Some industries and communities discharge their wastewater directly with little or no treatment into receiving bodies including Atoyac, Alseseca canyons and some rivers. The technological and industrial advances generated from the second half of the nineteenth century have resulted in multiple benefits for, suitable to personal needs humans.

Key words: Industrial parks, no running water, ravines, water quality.

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Introduction

Mexico currently has a population of approximately 112,336,538 million inhabitants, 5,779,829 million were located in the city of Puebla, (INEGI, 2010). The large population increase nationally and worldwide are demanding high volumes of water for human consumption and other equally important activities. Following are generating large amounts of waste water are sources of infection and toxicity to human health and the environment. The city of Puebla, Mexico, the state capital of the same name by the Department of Sustainability and Land Management reported that only 35 of the 278 plants wastewater treatment found in Puebla state work and are within the rule because it is expensive for municipalities that are responsible for putting them into operation (Camacho, 2013). However the problem of high river pollution is further complicated when the five wastewater treatment plants System Operator Water and Sewerage (SOAPAP) that exist in Puebla Puebla state capital only worked 60 percent of its capacity until 2012.

However it is clear that the pollution of these rivers are also generating industries dump their untreated sewage to the ravines and finally reach important water resources. The main use of water from rivers is Alseseca Atoyac and for agricultural irrigation zones and Izúcar Matamoros Atlixco and most of it is stored in the Manuel Avila Camacho Dam to supply the Irrigation District 030 "Valsequillo" seventeen municipalities benefiting area Tacamachalco-Tehuacan.

The Mexican Official Norm refers to the reuse of these effluents is the NOM-003-SEMARNAT-1997 (DOF, 2003), which establishes the maximum permissible limits for contaminants in treated wastewater reused in services to the public. Because WWTP Puebla state reach only treat wastewater by 50% NOM-001-SEMARNAT-1996 will also be used, (DOF, 2003), which establishes the maximum permissible limits of pollutants in discharges sewage water and domestic goods. It is clear that the Official Mexican Standards above do not regulate agronomic quality parameters, such as the content of soluble salts, sodium relative to other cations and content of toxic elements for plants, as these are widely used and recommended for the study of water quality for irrigation in Mexico and in other parts of the world (Villanueva and Hernandez, 2001;. Steves et al, 2003; Cueto et al, 2005;.. Rodriguez-Ortiz et al, 2009), will be conducted to determine these parameters according to the Mexican Standards NMX-AA in water.

Wastewater with high concentrations of dissolved salts must have a special handling to be used in agricultural irrigation, because the risk of increasing their concentration in the soil, and thus will cause a reduction in the osmotic potential of the solution soil, resulting in a reduction in total water potential in the soil and consequently causes a decrease in their availability to the crop and its performance (Castellanos et al., 2000). When sodium is in the water at high relative to other cations quantities, I could be that begins to be adsorbed in large quantities in the complex soil cation exchange, increasing the percentage of exchangeable sodium relative to other cations. This process results in the formation of a sodic soil representing a number of problems for agricultural crops, because it causes a colloidal dispersion which results in a drastic decrease in soil permeability also adverse conditions for development are generated crops present flooding and anaerobic conditions (Ortiz, 2000; Rodriguez-Ortiz et al., 2009). Among the toxic elements that are referred to by their toxic effect on plants even small amounts are: chlorine, boron and sodium. The first two are essential elements in plants, but only at concentrations above the necessary start to be toxic to some (Mass, 1884 crop, Rodriguez-Ortiz et al., 2009.

Glynn, 1999, mentions that the conventional processes of wastewater treatment do not include the direct elimination of all the above substances as they are removed only by advanced treatments. Because of this it is assumed that there is a high possibility that still remain in the water after passing through the WWTP, should have been present before processing. By the above is important determination and classification in effluents in order to propose appropriate use and management of this resource for sustainable productivity and rational use of natural resources is achieved. Meanwhile the federal government intends to meet this demand nationally by 60% by the year 2012, taking aim at a comprehensive and sustainable water management (Rodriguez-Ortiz et al., 2009). On the other hand within the National Development Plan as a strategy is to promote efficient use of water in agriculture, so that inadequate intake of fluid while protect soil salinization (NDP, 2007) is reduced.

By the above taking into account the great prevailing pollution in Atoyac and Alseseca rivers continues to affect largely agricultural soils, crops, animals and people of the city of Puebla, Irrigation District 030 "Valsequillo" and also in the area of irrigation and Izúcar Matamoros Atlixco, irrigated restricted by this pollution, this study was performed in order to determine the physicochemical and microbiological quality of effluents cased canyons located in two industrial parks (IP), Puebla and 5 May 2000 the city of Puebla. Mexico, to disseminate the results of monitoring of water quality and prevent the population from risks to health and thus help to make decisions to improve the conditions of important water resources.

Materials and methods

It was a prospective, descriptive and observational research, the sampling period was conducted in the first fortnight of May 2011 Decision of the piped water samples was organized in two main stages (planning and execution). During the planning stage of the study area was delimited, being made up of sections of rivers located within three canyons that constitute the physical limits of two industrial parks (IP) north of the town of Puebla on May 5 PI Puebla and PI 2000, shown in Figure 1; the first in its northeastern border surrounded by Guadalupe Canyon and on the east by a section of Canyon Del Conde, as shown in Figure 2, the second bounded on its eastern border by a section of San Antonio Canyon or Manzanilla exhibited in Figure 3, all formed and fed by runoff from the Malintzin extinct volcano.

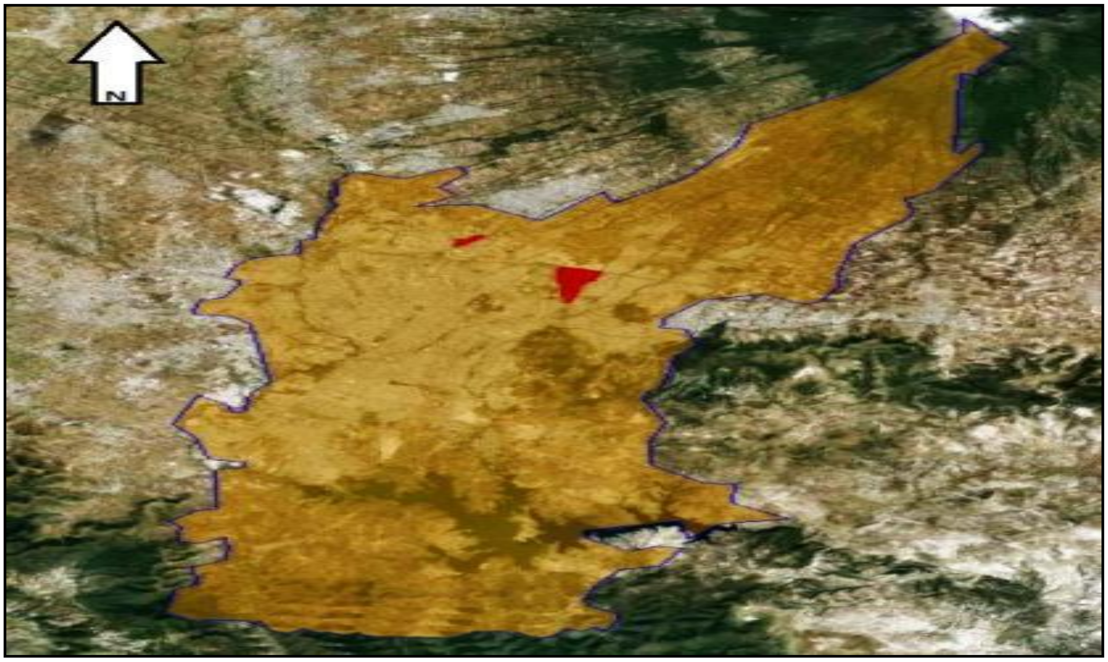

Figure 1 The municipality of Puebla (yellow), industrial parks (red) May 5 located north, south Puebla 2000.

Source: Own calculations based on INEGI / CONCYTEQ, 2010.

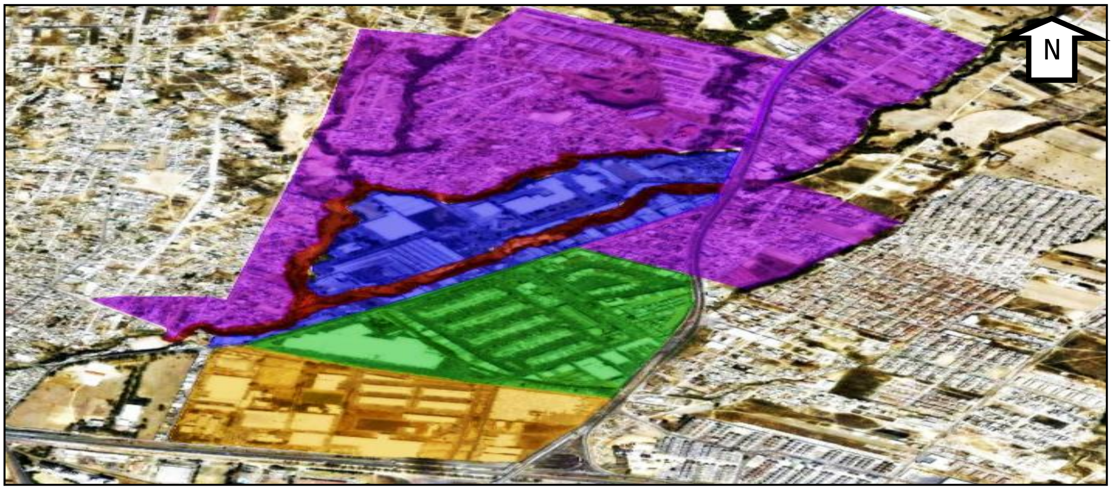

FIGURE 2 Industrial Park May 5 (blue), sections of canyons (red) Guadalupe north and south Conde, nearby colonies (purple), central supply of the city of Puebla (green) and Industrial Fractionation Count (orange).

Source: Authors' calculations based on fieldwork, 2011.

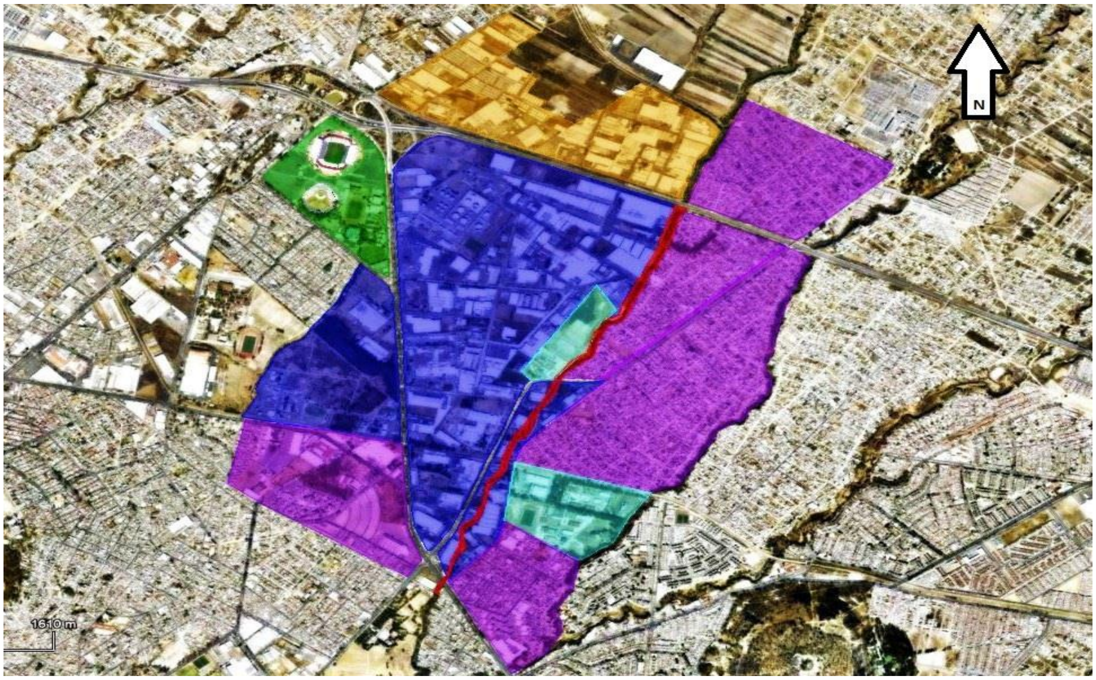

Figure 3 Puebla 2000 Industrial Park and nearby industries (blue), San Antonio Canyon section (red), nearby colonies (purple), and Cuauhtémoc Stadium Serdán Brothers (green), Industrial Park Resurrection (orange).

Source: Authors' calculations based on fieldwork, 2011.

After selecting the area of study visits were made to the authorities on water levels federal and municipal government, National Water Commission (CNA) and the Operator Water and Sewerage Puebla (SOAPAP) system respectively. To inquire exclusive competence for each level, so the CNA access to database downloads and permits use of water for industrial purposes firms in the industrial parks of interest was managed, planes as well as detailing the system of rivers crossing the city of Puebla in order to establish the possible discharge rate and trajectory of pollutants, such information is requested by the Federal

Institute for Access to Information and Institutional by trade, in both cases the answer was negative.

Only SOAPAP authorities, provided all the facilities to access interviews with officials from the same department, public consultation reports and a printed copy of the sewer system updated to 2009 the municipality of Puebla, which had previously been requested drawings or diagrams collectors wastewater systems in the city of Puebla and particularly those located near the study area so as well as the discharge volume calculated canyons as visits to industrial parks outputs drainage were observed industries and the established room in the margins of the three canyons houses. Thus, it was found that while the industrial parks are connected to the drainage and municipal sewage, a fraction of downloaders industries even outside the network; however, in the case of the residential area in the surrounding colonies PI 5 de Mayo is not the same as some (PI May 5 case) to be "new" does not yet have full utilities such as lighting , regulating garbage collection and public drainage, while others (PI case Puebla 2000) that already have prior service, maintain a wastewater drain into the ravines.The sampling grid shown in Figures 4 and 5, was established using satellite imagery and views collected from the zone information, where geographic coordinates were recorded, as well as access roads to the canyons ten stations being chosen for making samples distributed in the canyons of Guadalupe, San Antonio and Del Conde. For the election of the same is sought to represent best the characteristics of the total effluent, for which three main criteria were used: the accessibility of the sites, the existence of drains (industrial and medical) to the ravines and the provision of sites in the upper, middle and lower part of the channel.

Ten sampling stations were observed in Figures 4 and 5, were established using satellite imagery and information collected in view of the study area, where the geographic coordinates were recorded, as well as access roads to the canyons whichever chosen, these are distributed in the cliffs of Guadalupe, San Antonio and Del Conde. For the election of the same is sought to represent best the characteristics of the total effluent, for which three main criteria were used: the accessibility of the sites, the existence of drains (industrial and medical) to the ravines and the provision of sites in the upper, middle and lower part of the channel.

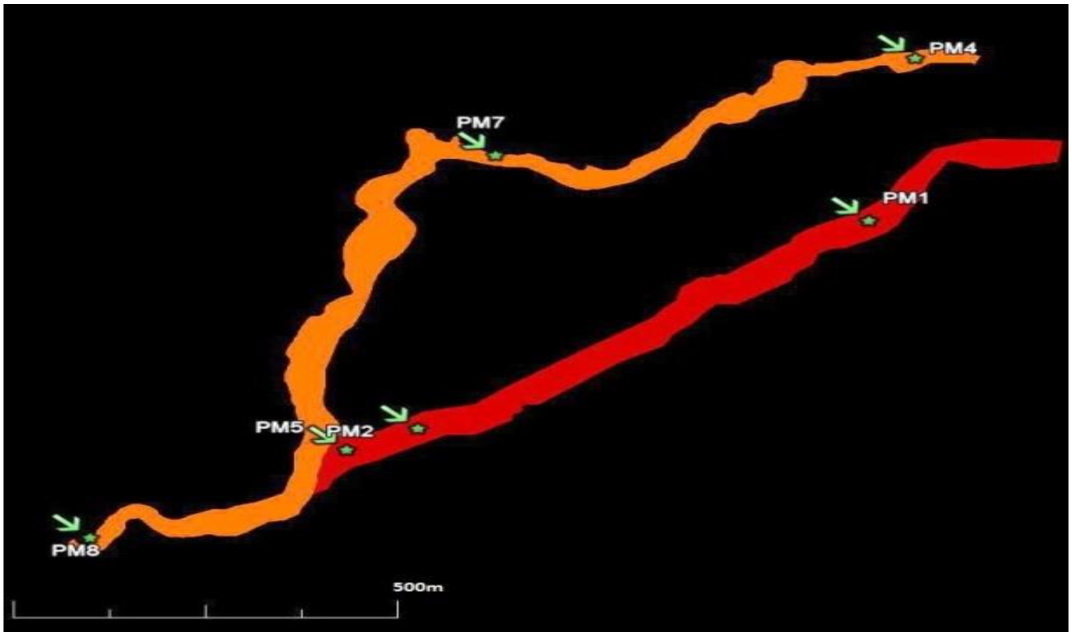

Figure 4 Sampling Network May 5 PI.

Source: Authors' calculations based on fieldwork, 2011.

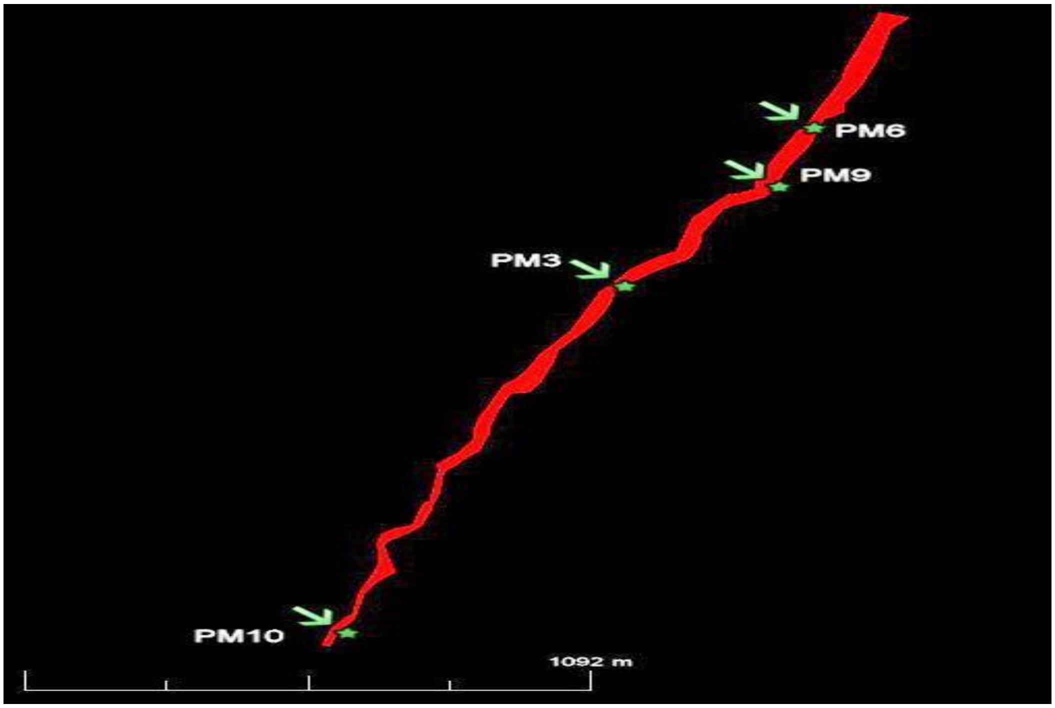

Figure 5 Network IP Puebla 2000 sampling.

Source: Authors' calculations based on fieldwork, 2011.

During the implementation stage sampling was performed, developed during the change between the dry season and rainfall. The methodology proposed by the technical standard NMX-AA-014-1980 (DOF, 1980) was considered. Current flow is measured using the float method, recording based on the average three replicates.

A total of ten samples no piped wastewater from two industrial parks (IPs) of the city of Puebla, Mexico, which differ from each other by different industrial processes and origin were taken, the taking of the samples was performed days 11, 13 and 16 May 2012 new washed polypropylene containers were used with 1N nitric acid solution, rinsed with deionized water several times and at the time of sampling water rinsed three times with the same water to be analyzed for fecal coliform analysis samples were taken in sterile flasks. The samples were placed in coolers and transported as soon as possible to the laboratory for analysis. Physical, chemical and bacteriological analyzes were determined according to Mexican standards on water.

The indicators measured effluent to determine the agronomic water quality in the sequence reported by (Rodriguez-Ortiz et al., 2009), adding other indicators for comparison of the maximum permissible limits of the Mexican Official Standards used in this work.

Electrical Conductivity (EC) which is used as an indirect measure of salt content: hazard assessment for the presence of salts by the following indicators were determined. It was determined with a portable conductivity meter Conductronic field, in the laboratory conditions of temperature taken in the field for testing with a conductivity Conductronic table reproduced; Salinity Effective (SE), which represents a more realistic estimate of the danger posed by soluble salts from irrigation water to become part of the soil solution, because it takes into account the subsequent precipitation of salts less soluble (calcium magnesium carbonate, calcium sulfate addition), which by then cease to participate in the elevation of osmotic pressure of the solution to the ground; Salinity Potential (SP), with which the risk of chloride salts and sulfate which can persist as soluble ions with decreasing soil moisture below 50% is estimated, was calculated from the formula SP = Cl + 0.5.SO42-

The sodium hazard indicators that were identified are: sodium adsorption ratio (SAR), which is one of the most widely used indices for measuring the risk of having sodification irrigation water; was calculated with the formula: RAS = Na [(Ca + Mg) -2] 1/2,. residual sodium carbonate (CSR), which estimates the risk of forming sodium carbonate after the precipitation of calcium and magnesium carbonates. It was calculated with the formula CSR = (CO3 + HCO3) - (Ca2 + + Mg2 +). The percentage of sodium possible PSP, which refers to the danger of displacement of calcium and magnesium for sodium on the exchange complex, begins when the sodium content in the solution represents more than half of the dissolved cations was also obtained . Reduced infiltration. It is obtained from the joint values of RAS and EC, including the FAO classification offered in three categories of water use restriction is used: none, mild to moderate and severe.

Cations and anions were measured according to the following methodologies: calcium and magnesium by complexometric titration with EDTA; sodium and potassium, by flamometría (flamómetro Corning 400), carbonates and bicarbonates by acid-base titration, volumetric chloride precipitation (Mohr's method), sulfates spectrophotometrically using the turbidimetric method.

As toxic chloride ion and sodium ion was evaluated. The other indicators evaluated were: temperature (T ° C), pH (potentiometric), floating material (physical), settleable solids (SSe), total suspended solids (TSS), total dissolved solids (TDS). For the classification of each of the parameters of Palacios methodologies and Aceves (1970), the Department of Agriculture of the United States (USDA, Riverside Laboratory) were taken. Were also considered methodologies Ayres and Westcot (1976) and Suarez (1981).

Water samples were taken directly from the currents of the discharges, were collected in clean, dry polypropylene containers with a capacity of 10.0 liters for physicochemical analysis, glass containers for fats and oils and for microbiological analyzes (fecal coliform) are they used sterile polypropylene containers with airtight lid donut-shaped 120 mL capacity, taking the sample directly from the runway. To perform laboratory analyzes of water samples were preserved under the NMX-AA-003-1980 standard and manual Eaton, 2005 And for bacteriological analysis were processed according to the procedures described in PROY NMX-AA-042/1-SCFI- 2008. Water Analysis - Detection and enumeration of coliform organisms, thermotolerant coliform organisms and presumptive Escherichia coli. (Ministry of Economy, 2005).

In Table 1 are shown: the location, geographical coordinates, height and name of the industrial park of the ten sampling stations wastewater.

Cuadro 1. Location of the sampling stations

E	Ubicación	Geographical coordinates		Altitude msnm	Industrial Park
		North	West		
1	Barranca del Conde I	19°05’47.70”	98°11’10.28”	2225	5 de mayo
2	Barranca del Conde II	19°05’35.83”	98°11’30.50”	2200	5 de mayo
3	Barranca de San Antonio	19°03’57.90”	98°09’09.50”	2227	Puebla 2000
4	Barranca de Guadalupe	19°05’58.70”	98° 11’08.20”	2225	5 de mayo
5	Barranca del Conde III	19°05’32.40”	98° 11’33.70”	2193	5 de mayo
6	Barranca de San Antonio I	19°04’18.10”	98° 08’57.00”	2238	Puebla 2000
7	Barranca de Guadalupe	19°05’52.18”	98°11’27.02”	2247	5 de mayo
8	Barranca del Conde (Avenida gasoducto)	19°05’26.50”	98° 11’45.20”	2192	5 de mayo
9	Barranca de San Antonio II (atrás de Sony Gas)	19°04’10.60”	98° 08’59.30”	2219	Puebla 2000
10	Barranca de San Antonio III (puente antigua Pepsi)	19°03’13.70” N	98° 09’27.80”	2193	Puebla 2000

Results and discussion

Indicators danger of salts

In Table 2 the results of the parameters considered as indicators of the danger of soluble salts are shown.

Regarding the electrical conductivity, it was found that stations 4, 6, 7, 9 and 10 are highly saline waters, the minimum value corresponding to station 7 (May 5 PI) of 0.87 d Sm-1, and maximum value at the same station 5 (PI) of 4.16 d Sm-1, with an average of 2.32 d Sm-1 being the other nine stations classified as very highly saline water.

Regarding the SE was obtained a minimum value of 3.06, a maximum of 17.37 and an average of 10.62 meq all L-1, where stations 1, 2 4, 5, 6, 7, 8 and the average which they were classified as conditioned water and stations 3, 9, and 10 were classified as not suitable water.

For the SP values ranging from 1.63 to 11.87 meq L-1 with mean value of 5.42 meq L-1, being classified as good stations 4, 6, 7 and 8 and as conditioned station 1, 2, 3 are obtained, 5, 9 and 10 and the average and conditional.

Risk indicators showed that use salts for irrigation of most waste water piped from the PI and Puebla on May 5, 2000 are not recommended mostly be used and must be done under careful management type non salinize preventive agricultural soils that are scattered or not to increase the content of salts. The increase in soil salinity causes reduced crop production.

The problem with salt is restricted to regions with limited rainfall (such as Irrigation District 030 "Valsequillo" where the stored water from the dam Manuel Avila Camacho known as Valsequillo is used, where rainfall is scarce and are not of sufficient magnitude to displace the salts of the soil profiles), Castellanos et al., 2000 mentioned normally in regions with more than 600 mm of rain salinization risk is high if the irrigation water is not of such poor quality. It is estimated that the salt-affected area in Mexico is about one million ha, Mexico is about one million (Fernandez, 1990)

Table 2 Classification of piped water is not PI and Puebla on May 5, 2000 regarding the content of soluble salts

E	CE dS m^{-1}	SE meq L^{-1}	SP meq L^{-1}
1	3.26	10.53^{C}	5.81^{C}
2	2.96	9.83^{C}	6.84^{C}
3	2.72	17.37 *	5.06^{C}
4	1.26*	5.76^{C}	1.63^{B}
5	4.16	14.73^{C}	11.87^{C}
6	1.31*	5.28^{C}	2.47^{B}
7	876*	3.06^{C}	2.85^{B}
8	2.92	8.48^{C}	2.95^{B}
9	1.98*	15.90 *	8.06^{C}
10	1.74*	15.24 *	6.68^{C}
PROM.	2.32	10.62^{C}	5.42^{C}
Min	876	3.06	1.63
Max	4.16	17.37	11.87
CLASF.	*Agua salina **Agua altamente salina	^{C} Condicionada *NR No Recomendable	^{B} Buena ^{C} Condicionada

It is important to take into account all possible factors involved in the process of crop production for the proper management of conditioned water, including: crop, soil, irrigation method, climate, internal drainage, etc. Among the treatments to prevent soil salinity to irrigate with groundwater includes options such as desalination by distillation or reverse osmosis and deionization using different exchange resins (Ortiz, 2000 and Rodriguez-Ortiz et al., 2009) . However, the same authors mention that these processes require a costly energy expenditure to take place on a large scale. Alternatively, soil washing, where the salts are displaced soil profile where the roots are growing so that they are equal to the provided poe irrigation water. . Rodriguez-Ortiz et al, 2009) mention that Rhoades and Merrill (1976) established the equation for calculating the requirement of washing:

$$L\boldsymbol{R} = \frac{\boldsymbol{EC_w}}{\mathbf{5}(\boldsymbol{ECe}) - \boldsymbol{EC_w}}$$

Where:

LR = minimum requirement to control leaching salts with surface irrigation methods
ECW = Salinity of applied water (dS m-1)
ECe = average soil salinity tolerated by the crop (dS m-1)

Washing is far more effective against primary salinization improvement and to prevent secondary salinization, Flores et al. (1996). The washing of soils without the use of penetration enhancers promotes sodium adsorbent complex, due to the relative increase in activity of sodium to calcium in solution and this is the need to expand the use of the same in all soils saline as a precautionary measure as sodification Rodriguez-Ortiz et al Otero explains, (1993)., 2009), on the other hand Aceves (1987) mentions that the use of enhancers is based on the application of substances containing calcium to promote its increase in soil solution and exchange with the adsorbed sodium to that after being removed by washing. In this way the soil is kept flocculated and the pH is neutralized.

If necessary, it may involve setting tolerant crops existing salinity. This option is somewhat complicated in the sense that there is always a tolerant crop or semitolerante can partially or totally substitute crops of economic importance of the area for market reasons.

One of the measures proposed and are cited by Rodriguez-Ortiz et al., 2009, is to implement a system of cultivation of rest and rotation with green manure, so the addition of salts is avoided for a while soil by irrigation saline water, while some benefits such entrainment by rain by consulting the organic material inducing the formation of aggregates which improve soil structure and better movement of salts obtained in the soil profile (Martinez et al, 1986;. Cifres and Miller, 1988; Otero et al., 1993).

Sodium Hazard Indicators

The concentrations of the sodium hazard indicators that were considered for the realization of this work were: sodium adsorption ratio RAS, residual sodium carbonate CSR and the percent of possible sodium PSP shown in Table 3.

The sodium adsorption ratio RAS showed values from 1.71 to 8.67 meq L-1 with a mean value of 4.64 meq L-1 according to the classification of Palacios Aceves (1994) that relates the RAS with the electrical conductivity, the water does not ducted were classified as follows: for stations 4, 6 and 7 as C3-S1, C3: highly saline water should not be used on soils with drainage is poor and must therefore selected only those very tolerant plant species salts and S1: low-sodium water may be used for irrigation in most soils with little likelihood of dangerous levels of exchangeable sodium. Stations 9 and 10 were classified as C3-S2, where S2: media-sodium water, which in fine textured soils sodium represents a significant danger even if the soil have a high CEC, especially under conditions of poor wash unless soil containing gypsum. Only be used in coarse-textured soils or organic soils with good permeability. Stations 1, 2, 5 and 8 were classified as C4-S2 where C4: corresponds to very highly saline water not suitable for irrigation under ordinary conditions, and can be used occasionally under very special circumstances. Soils must be permeable, proper drainage, and must apply an excess of water to achieve a good wash. In this case should be selected high salt tolerant crops; Finally the station station 3 I remain classified as C4-S3 where S3: High water in sodium, can produce toxic levels of exchangeable sodium in most soils, requiring special management practices, good drainage, easy to wash and additions organic matter. The gypsum soils may not develop harmful levels of exchangeable sodium when irrigated with such water. May require the use of chemical enhancers for replacing the exchangeable sodium; however, such enhancers are not economical when high salinity water used.

Cuadro 3. Clasificación del agua respecto al efecto probable del Na sobre las características físicas del suelo

E	***RAS meq L^{-1}**	***CE µS cm^{-1}**	****CSR meq L^{-1}**	**PSP meq L^{-1}**	**Clasificación CE y RAS**
1	**5.03 ^{B}**	**3260**	**2.22 ^{C}**	**91.79**	**(C4-S2)**
2	**3.81 ^{B}**	**2960**	**0.00 ^{B}**	**88.49**	**(C4-S2)**
3	**8.67 ^{B}**	**2720**	**8.79 ^{NR}**	**94.79**	**(C4-S2)**
4	**2.70 ^{B}**	**1265**	**2.71 ^{C}**	**87.03**	**(C3-S1)**
5	**4.70 ^{B}**	**4160**	**0.00 ^{B}**	**91.59**	**(C4-S2)**
6	**1.99 ^{B}**	**1309**	**0.96 ^{B}**	**78.22**	**(C3-S1)**
7	**1.71 ^{B}**	**876**	**0.00 ^{B}**	**84.89**	**(C3-S1)**
8	**3.59 ^{B}**	**2920**	**4.03 ^{NR}**	**89.69**	**(C4-S2)**
9	**6.61 ^{B}**	**1985**	**4.62 ^{NR}**	**91.96**	**(C3-S2)**
10	**7.55 ^{B}**	**1742**	**5.91 ^{NR}**	**91.99**	**(C3-S2)**
PROM.	**4.64 ^{B}**	**2319.7**	**2.92 ^{NR}**	**89.04**	**---**
Min.	**1.71**	**876**	**0.00**	**78,22**	**C3-S1**
Max.	**8.67**	**4160**	**8.79**	**94.79**	**C4-S2**
CLAS.	**--**		**--**	**C**	

* Methodology USDA, RAS Low (B) <10; Mean (M) 10 to 18; High (A) 18-25; Very High MA> 25

* Methodology USDA. CE: Low <250; Middle 250-750; Alto 750-2250; Very high> 2250 µScm-1

Methodology ** Palacios and Aceves 1994 B = good C = conditional; NR = not recommended

Toxic Cl Ion Indicator

As for the concentrations of the chloride ion whose values are shown in Table 4, it is observed that ranged from 1.00 to 7.30 meq L-1, with an average of 3.38 meq L-1 except station 4 being at the edge of the rated as good, seasons 1, 2, 3, 6, 7, 8 and 10 showed lower values of 5.00 meq L-1 being classified as conditional and stations 5 and 9 were classified as not recommended.

Rodriguez-Ortiz et al., 2009 mentioned that the improvement of conditional wastewater treatment plant level can be performed by tertiary treatment, also known as advanced. Some treatments like reverse osmosis, activated carbon, electrodialysis and others could be used to remove these substances, however, is not yet implemented in all treatment plants, but that the future will be implemented as the need for water reuse (Ramalho, 1996).

Table 4: Classification of water relative to Cl^- ion content

E	Cl^- meq L^{-1}	Clasificación Aceves y Palacios, 1994	Metodología de la FAO
1	3.64	Condicionada	Ligera a moderada restricción
2	4.32	Condicionada	Ligera a moderada restricción
3	3.16	Condicionada	Ligera a moderada restricción
4	1.00	Buena	Ninguna restricción
5	7.30	No Recomendable	Ligera a moderada restricción
6	1.54	Condicionada	Ninguna restricción
7	1.76	Condicionada	Ninguna restricción
8	1.82	Condicionada	Ninguna restricción
9	5.06	No Recomendable	Ligera a moderada restricción
10	4.20	Condicionada	Ligera a moderada restricción
PROM	3.38	Condicionada	Ligera a moderada restricción

Min	**1.00**	-----	-----
Max	**7.3**	-----	-----

Ayers and Wescot (1985) cited by Rodriguez-Ortiz et al., 2009 mention that care must be taken when crops are irrigated by sprinkling, because the Cl can also be absorbed by the aerial parts of the plant. This situation poses a problem for the treated effluent no piped water that is dumped into rivers and subsequently be used for crop irrigation, and chloride values ranged from 1.00 to 7.30 me L-1. However, care must be taken joint action of water and soil Mengel and Kirkby since (1982) note that the crops grown in salt-affected soils often show symptoms of Cl toxicity, these include burning tips or margins, browning and premature leaf yellowing and separation. The reduction in yield and quality of the crop is associated with levels of 0.5% Cl in tissue to sensitive crops and 4% or more in dry matter tolerant crops.

Physical and chemical indicators

The physicochemical parameters determined for the classification of water quality are shown in Table 5, where the results were compared with the maximum permissible limits of the NOM-001-SEMARNAT-1996 and NOM-003-SEMARNAT-1997 (DOF, 2003).

The pH values ranged from 5.7 to 7.7 with a mean value of 7.07 pH units, none of them not exceeding the maximum permissible limit of NOM-001, Seasons 1, 2 and 6 had pH less than 7.0, station 9 showed pH = 7 (neutral) and greater than 7.0 were stations 3, 4 5 7 8 and 10 securities classified as permissible under Mexican law, as to the classification of FAO only stay out season 6 range, which is 6.5 8.4, featuring an acid value.

Electric conductivity expressed in mS cm-1 finding one of the most important parameters in the determination of the quality of an irrigation water, since it provides information on the concentration of soluble salts. In this research, the minimum value obtained was 876 mS cm-1 in station 7 the maximum was 4160 mS cm-1 at station 5 finding average 2319.70 mS cm-1, the stations had values below 70 mS 2000 cm-1 were the lowest to the highest 7.4, 6, 10 and 9 and the major 2000 mS cm-1 corresponded to the stations 3, 8, 2, 1 and 5 being the latter as conditioned to irrigation according to Palacios and Aceves (1994).

Table 5 Results of the physical parameters of the ten sampling stations no piped wastewater.

E	Caudal m^3 s^{-1}	Temp. °C	Materia flotante	pH unidades	CE µS cm^{-1}	SSe mg L^{-1}	SST mg L^{-1}	SDT mg L^{-1}
1	0.043	19.0	Presente	6.8	3260	6.0	37.78	2086.40
2	0.546	21.0	Presente	6.7	2960	5.0	338.46	1894.40
3	0.717	25.5	Presente	7.4	2720	3.5	316.67	1740.80
4	0.031	17.5	Ausente	7.3	1265	0.0	8.89	809.60
5	0.683	20.5	Presente	7.3	4160	7.5	566.67	2662.40
6	0.004	22.0	Ausente	5.7	1309	0.5	100.00	837.76
7	0.050	16.0	Presente	7.6	876	0.8	37.50	560.64
8	0.848	18.5	Presente	7.7	2920	1.6	138.10	1868.80
9	0.311	25.5	Presente	7.0	1985	3.5	26.30	1270.40
10	0.003	25.1	Ausente	7.2	1742	1.5	50.0	1114.88
Prom	0.324	20.65	----	7.07	2319.70	2.99	162.04	1484.61
Mín	0.003	16.00	----	5.7	876	0.0	8.89	560.64
Máx	0.848	25.5	----	7.7	4160	7.5	566.67	2662.4
*LMP	NN	40	Ausente	5 - 10	NN	2	125	NN
**LMP	NN	NN	Ausente	NN	NN	NN	30	NN

* LMP: Reference NOM-001-SEMARNAT-1996; LMP: reference NOM-003-SEMARNAT-1996. NN: Parameter not regulated.

Settleable solids (SSe) ranged from 0.0 to 7.5 mL L-1 with a mean of 2.99 mL L-1, stations 4, 6, 7, 8 and 10 were within the limit of 2.0 mL L-1 and seasons 1, 2, 3, 5 and 9 as surpassed. Total suspended solids showed a variation of 8.89 to 566.67 by a mean value of 162.04 mg L-1, the average can be regarded as an average concentration in terms of this parameter and although is not regulated, is important determination since the chemical elements metal are attached to these particles in suspension, also representing a problem for pressurized irrigation systems, especially drip problem that can be solved by removing suspended solids through primary treatment with various types of filtration systems available in the market as hydrocyclone, sand filters, mesh filters and disc filters

(Montalvo, 2000 and Rodriguez-Ortiz et al., 2009). Total dissolved solids ranged from 560.64 to 2662.40 mg L-1 with an average of 1434.64 mg L-1 the values of the stations 2, 3, 4, 6, 7, 8, 9 and 10 and the average was classified by slight to moderate restriction and stations 1 and 5 show a severe restriction, according to the FAO methodology, the average value is considered problematic for gravity irrigation, but irrigation systems can generate localized clogging problems without But the problem can be avoided by keeping the pH slightly acidic water.

Chemical indicators

Table 6 shows the concentrations of the major chemical parameters for determining agronomic water for irrigation is

The concentrations of fats and oils gave values of 56.0 to 1227.27 mg L-1 with an average of 615.13 mg L-1, all stations exceed the maximum permissible limits of Mexican standards used in this study of 15 mg L-1.

The BOD5 showed a range of 405.27 to 7294.83 mg L-1 with an average of 3566.36 mg L-1, a large proportion exceeding the maximum permissible limits of the standards from 150.0 mg L-1 of NOM-001 and 30.0 of the NOM-003.

The NT ranged from 28.0 to 56.0 mg L-1 with a mean of 34.40 mg L-1 not exceeding the regulated value.

The alkalinity in mg L-1 as CaCO3 ranged from 238.30 to 1191.50 mg L-1 with an average of 822.14 mg L-1, parameter not regulated and is essential to determine the agronomic quality of water for irrigation.

Among the anions chloride expressed in mg L-1 ranged from 35.45 to 258.79 mg L-1 with an average value of 119.82 mg L-1. As the sulphate concentration variation in mg L-1 was from 89.54 to 288.48 to 196.21 and average both parameters are not regulated and are of fundamental importance in determining the agronomic quality of the water.

Total hardness as CaCO3 showed values of 232.21 to 824.74 mg L-1 with mean value of 436.39 mg L-1. The Ca2 + ions gave values of 67.33 to 211.62 with a mean of 116.07 mg L-1 Mg2 + ion showed values of 9.76 to 72.26 mg L-1 with a mean value of 35.74 mg L-1. For the Na + value was obtained between 59.80 to 378.60 mg L-1 with an average of 221.42 mg L-1 and K + showed values of 18.10 to 50.0 mg L-1 with a mean value of 38.60 mg L-1, all these cations are not considered by Mexican standards are indispensable for determining agrological irrigation water.

Parámetros Químicos	**Unidades**	**ESTACIONES DE MUESTREO**										**PROM**	***LMP**
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**		
G y A	**mg L^{-1}**	**1227.27**	**1000.00**	**295.00**	**1032.20**	**792.00**	**383.00**	**56.00**	**232.00**	**783.80**	**350.00**	**615.13**	**25.00**
DBO_5	**mg L^{-1}**	**405.27**	**5268.49**	**7294.83**	**4052.68**	**5268.49**	**1621.07**	**4052.68**	**2026.34**	**405.27**	**5268.49**	**3566.36**	**150.00**
N_T	**mg L^{-1}**	**28.00**	**28.00**	**28.00**	**56.00**	**42.00**	**56.00**	**28.00**	**42.00**	**28.00**	**28.00**	**36.40**	**60.00**
Alcalinidad como $CaCO_3$	**mg L^{-1}**	**714.90**	**714.90**	**1191.50**	**714.90**	**953.20**	**714.90**	**238.30**	**953.20**	**1072.35**	**953.20**	**822.14**	**NN**
Cl^-	**mg L^{-1}**	**129.04**	**153.14**	**112.02**	**35.45**	**258.79**	**54.59**	**62.39**	**64.52**	**179.38**	**148.89**	**119.82**	**NN**
SO_4^{2-}	**mg L^{-1}**	**208.23**	**242.29**	**182.17**	**60.12**	**439.43**	**89.54**	**105.02**	**108.12**	**288.48**	**238.68**	**196.21**	**NN**
P_T	**mg L^{-1}**	**49.70**	**4.29**	**0.57**	**0.04**	**5.57**	**55.78**	**0.08**	**2.82**	**49.18**	**0.69**	**16.94**	**30**
D_{Total} como $CaCO_3$	**mg L^{-1}**	**368.33**	**520.47**	**360.32**	**344.31**	**824.74**	**432.39**	**232.21**	**448.40**	**488.44**	**344.31**	**436.39**	**NN**
D_{Ca2+} como $CaCO_3$	**mg L^{-1}**	**168.15**	**408.37**	**224.20**	**232.21**	**528.48**	**376.34**	**192.17**	**312.28**	**240.22**	**216.19**	**289.8**	**NN**

D_{Mg2+} como $CaCO_3$	**mg L^{-1}**	**200.18**	**112.10**	**136.12**	**112.10**	**296.27**	**56.05**	**40.04**	**136.12**	**248.22**	**128.12**	**146.53**	**NN**
Ca^{2+}	**mg L^{-1}**	**67.33**	**163.53**	**89.78**	**92.99**	**211.62**	**150.70**	**76.95**	**125.05**	**96.19**	**86.57**	**116.07**	**NN**
Mg^{2+}	**mg L^{-1}**	**48.82**	**27.34**	**33.20**	**27.34**	**72.26**	**13.67**	**9.76**	**33.20**	**60.54**	**31.25**	**35.74**	**NN**
Na^{+}	**mg L^{-1}**	**222.20**	**199.90**	**378.60**	**115.20**	**310.10**	**95.00**	**59.80**	**174.90**	**336.2**	**322.3**	**221.42**	**NN**
K^{+}	**mg L^{-1}**	**33.80**	**44.20**	**35.40**	**29.20**	**48.40**	**45.00**	**18.10**	**34.20**	**50.00**	**47.70**	**38.60**	**NN**

Cuadro 6. Concentraciones de los parámetros fisicoquímicos de las muestras de aguas residuales no entubadas en mg L^{-1}

Microbiological indicators

Regarding the content of fecal coliforms in 10 wastewater samples analyzed, the results revealed a concentration> 2 .4 X 106 CF 100 mL-1, so that the quality of water for agricultural use with this bacteria content does not meet and exceeds the limits set in the Mexican Official Standards NOM-001-SEMARNAT-1996 (2000 FC 100 mL-1 as a result of an analysis on a single sample) and NOM-003-SEMARNAT-1997, the geometric mean for at least 2 single samples in one month (1000 CF 100 mL-1 for water samples reuse for public service or occasional direct contact).

From a bacteriological point of view, the main disadvantage of using untreated water for irrigation waste is the presence of bacteria, viruses and parasites that can pose risks to the health of farmers and communities that are in prolonged contact with water waste and consumers of products irrigated with contaminated water (Bonilla et al, 2005;. Bonilla et al, 2008;. Cabrera et al, 2005;. Cabrera et al, 2012;. Diaz et al., 2005). Although this type of water brings a great benefit that is reflected in an increase in soil fertility, crop diversification also contributes to a dispersion of pathogens in water, soil, air, groundwater and crops, as a possible incorporation into the soil of toxic substances, metals, pesticides and organic wastes with low degradation rate. Water treatment is at least theoretically the best option to protect human health and effective treatment methods and low cost, to eliminate pathogens but at the same time retain the nutrients in the water are needed.

Conclusion

Agronomic classification samples of raw sewage piped thrown into the canyons for some industries PI May 5th understood Seasons: 1, 2, 4, 5, 7 and 8 which were found were very heterogeneous, were classified according to hazard indicators and sodium salts as shown in Table 7.

Indicator	**PI sampling station May 5**					
	1	**2**	**4**	**5**	**7**	**8**
CE	**AS**	**AS**	**AS**	**AAS**	**AAS**	**AAS**
SE	**C**	**C**	**C**	**C**	**C**	**C**
SP	**C**	**C**	**B**	**C**	**B**	**B**
RAS	**B**	**B**	**B**	**B**	**B**	**B**
CSR	**C**	**B**	**C**	**B**	**B**	**NR**
PSP	**C**	**C**	**C**	**C**	**C**	**C**
Cl-	**C**	**C**	**C**	**C**	**C**	**C**
Clasf. RAS-CE	**AMAS media en Na**	**AMAS media en Na**	**AAS baja en Na**	**AMAS media en Na**	**AAS baja en Na**	**AMAS media en Na**

AAS = salt water, AMAS = highly saline water

And for agronomic classification PI Puebla 2000 that included stations 3, 6, 9 and 10, also were found were very heterogeneous, being classified according to indicators of risk of salts and sodium as shown in Table 8.

Indicator	**Sampling stations PI Puebla 2000**			
	3	**6**	**9**	**10**
CE	**AAS**	**AS**	**AS**	**AAS**
SE	**NR**	**C**	**NR**	**NR**
SP	**C**	**C**	**C**	**C**
RAS	**B**	**B**	**B**	**B**
CSR	**NR**	**B**	**NR**	**NR**
PSP	**C**	**C**	**C**	**C**
Cl-	**C**	**C**	**C**	**C**
Clasf. RAS-CE	**AMAS media en Na**	**AAS baja en Na**	**AAS baja en Na**	**AMAS alta en Na**

The results obtained show that the effluent of the ten stations waste water piped that are thrown to the ravines by PI 5 de Mayo and Puebla 2000 and municipal discharges around, are agronomic quality conditioned and not recommended for most sampling stations.

As the concentrations of the parameters governing the Mexican Official Standards NOM-001-SEMARNAT-1996 and NOM-003-SEMARNAT-1997 floating matter (Average = present), settleable solids (SSe) (Average = 2.99 mL L-1), total suspended solids (TSS) (mean = 162 mg L-1), biochemical oxygen demand (BOD5) (Mean = 3566.36 mg L-1), fats and oils (Gy A), (Mean = 615.13 mg L-1) greatly exceed the maximum permissible values of the official Mexican standards ..

As for the fecal contamination from pathogens in the water that cause enteric diseases in humans, all samples of waste water not piped, exceeded the maximum limits for current regulations ermisibles presenting concentrations> 2 .4 X 106 CF 100 mL-1

Although the results are very heterogeneous for both industrial parks, it is necessary that the practices continue to be implemented by some industries PI 5 de Mayo and Puebla 2000 shed effluent wastewater with little or no treatment illegal and indiscriminate canyons without meeting current regulations, so it is monitored and regulated by corresponding Secretary because otherwise, it will remain that the cause of the high contamination of Atoyac and Alseseca rivers and pollution continue to prevail, it will be very difficult the rescue of these important water bodies and therefore will remain affected by this contamination plots growing areas Tecamachalco-Tehuacan and Atlixco and Izúcar Matamoros, besides the great deterioration of the health of the inhabitants of the state of Puebla.

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