Towards a sustainable scheme of reclaimed wastewater reuse in Chihuahua, Mexico

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Abstract

Wastewater reclamation and reuse is an economically promising alternative to mitigate the effects of water scarcity and it plays a significant role to achieve a sustainable development, especially in arid regions. Benefits of wastewater reclamation and reuse are: protection of water resources, recovery of nutrients, groundwater recharge and sustainability of water resource management. Chihuahua relies entirely on groundwater as its potable water source. Due to an overdraft of aquifers, new sources to support future demands of drinking water are needed. One strategy implemented is wastewater reclamation and reuse upon activities where drinking quality is not required. The city has two treatment facilities which use activated sludge as the principal process; a part of the disinfected effluent is delivered through a non potable distribution system to public gardens, boulevards, educative institutions, sports and recreational centers, golf fields and manufacturing industries. The quality of restored water is monitored at the exit of plants, but there is no information in pumping stations, storage tanks and the sites where people are. Otherwise, samples are analyzed for Faecal Coliform bacteria, but nothing is done about protozoan pathogens which can cause numerous waterborne outbreaks. This preliminary study will contribute to evaluating, in a global form, the reuse practice done in Chihuahua, with the objective of releasing specific guidelines and strategies conducted to use best management practices in the planning, design, construction, operation and management of reclaimed and reuse system, to benefit the environment through an economic and ecologically sustainable scheme.

Keywords: groundwater, wastewater reclamation, reuse, sustainability, strategies, guidelines.

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1 Introduction

A holistic environmental approach to public sanitation includes not only wastewater collection and treatment, but also another important component which is reclaimed water use. Reclamation and reuse programs should be a priority of any sustainable water resource management scheme to confront the increasing global water crisis, reducing the dependence on natural superficial water and groundwater. It has been proved that wastewater reuse also would reduce the costs of imported water in cases of water scarcity [1]

The plan of resolutions of the 2002 World Summit on Sustainable Development includes the development of waste management systems considering reuse and recycling in order to minimize adverse effects on the environment and improve resource efficiency [2].

Benefits of the reclaimed water use reflect on alleviation of some requirements of water supply, providing an alternative and secure source for irrigation, protecting of water resources avoiding disposal of wastewater to surface bodies which impacts downstream users and ecosystems, the recovery of nutrients for agriculture, augmentation of river flow and groundwater recharge [3].

The objective of this study was to perform a preliminary diagnosis of the actual situation of reclaimed water use in the city of Chihuahua, Mexico, which contributes to develop specific guidelines and strategies conducting to reach the sustainability of water resource management in this arid region of the world.

2 General features of the studied area

The city of Chihuahua is situated in the North of Mexico between 105^{o} and 106^{o} West longitude and 28^{o} and 29^{o} North latitude, which is the same location as the largest deserts in the world (Figure 1). The territorial extension is 9,219 km^{2} with a population near to 750,000 inhabitants. The climate is arid, with 415 mm of annual-media pluvial precipitation against an annual-media evaporation rate of 2,900 mm.

This locality, like the majority in the area, relies entirely on groundwater as its potable water source. The growth of the city has been related with an accelerated development of the industrial sector shown in recent years. As a consequence, a considerable deficit of fresh water exists due to overdrafts of aquifers used for drinking water supply [4]; therefore new sources of water or limitation of actual groundwater extraction are needed to support future demands. One of the strategies implemented, in order to lighten water shortage, is wastewater reclamation and treated effluent reuse in activities where drinking quality is not required.

The city has two facilities named Planta Norte and Planta Sur which treat 90% of the total discharged wastewater at the sewage system (2200 liter per second). Both facilities use activated sludge as treatment processes including sieving, sand clearing, grease elimination, primary clarification, aeration and

secondary sedimentation with sludge recycling to biological reactor. The effluent is disinfected with chlorine before being discharged to Sacramento River or, as in Planta Norte occurs, addressed toward the reclaimed water program. The non potable distribution system consists of five pumping stations facilities with 150 Km of running pipes to carry about 300 liters per second of reclaimed water for irrigation of public parks and gardens, boulevards, public and private educative institutions, sports and recreational centers, golf fields and manufacturing industries. The irrigation area reaches an extension of 1,200 Ha in the Northern part of the city (Figure 2).

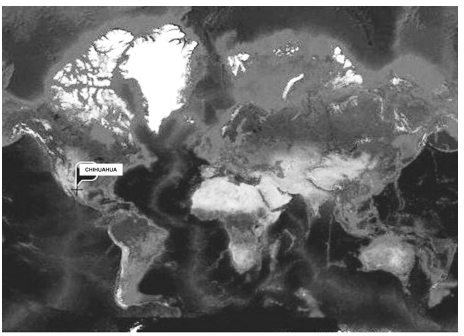

Figure 1: Location of the city of Chihuahua.

Figure 2: Reclaimed water use system in Chihuahua.

3 Methodology

To perform this preliminary study, information about reclaimed water quality was collected and compared with existing regulations for reuse of wastewater in Mexico.

In addition, the principal sites of application of reclaimed water in the city were selected to realize a survey of public opinion related with the perceptions about the origin, nature, and actual use of reclaimed water. The social acceptance concerning the irrigation with this water was analyzed by means a questionnaire applied to 49 users in 7 public gardens, 5 educative institutions and one industrial park. The reclaimed water system functioning was known from opinions of 17 managers of irrigation devices in the same areas.

4 Results and discussion

Reclaimed water samples were analyzed for basic physical and chemical parameters giving the following mean monthly results: 9 mg/L of total suspended solids (TSS), 43 mg/L in chemical oxygen demand (COD), 23 mg/L in biochemical oxygen demand (BOD), 38 mg/L of total nitrogen, 1.3 mg/L of surfactants and 6 mg/L of oil and grease. Metal concentration was lower than drinking water limits. On the other hand, the microbial quality of reclaimed water was measured as Helminth eggs and Faecal Coliform bacteria in the wastewater treatment effluent giving non detectable results. Another important point is that this effluent showed 0.9 mg/L of residual chlorine at the end point of facility.

As we can see, the treated effluent agrees with actual Mexican regulation related to the reuse of wastewater for activities only where the public is not in direct contact with reclaimed water [5]; such limits are 30 mg/L for BOD and TSS concentrations, as well as 15 mg/L related to oil and grease. However, it doesn't agree with the requirements of 20 mg/L of BOD and TSS for services that implies direct contact with reclaimed water.

In terms of biological characteristics, reclaimed water agrees with the direct contact rule for contents of Helminth eggs (1 egg/L) and Faecal Coliform bacteria (240 MPN/100 mL). However, nothing is said about viruses and protozoan pathogens as Giardia and Cryptosporidium which represent a significant human health threat in regards to chlorinated water and may cause numerous waterborne outbreaks [6].

An important observation, on the other hand, is that the quality of restored water is only monitored at the exit of wastewater treatment plants, and there's not information about this matter in pumping stations, storage tanks and the application sites where people are.

Results of the survey of public opinion about personal appreciation related with the use of reclaimed water for irrigation are in Table 1. From a sample of 49 public users, is noticeable that almost 70 % of people declared to have had direct contact with water and plants and 31 % of users have eaten any kind of food on

irrigated areas with reclaimed water. The worst fact is that some people accepted to have drunk this water, due to the lack of enough signs indicating its nature and origin. A considerable number of users (53%) declared to have perceived unpleasant odors near from irrigated areas. On the other hand, from a sample of 17 managers of reclaimed water in irrigated areas, 41% regularly perceive disgusted odor and the rest 59% never or seldom does it. Almost all of them commented that sprinklers obstruction with solids frequently occurs. A very important feature is that none of all these 66 people had any knowledge about reclaimed water quality neither of guidelines or regulations for reclaimed water uses. Operators of irrigation system have never been trained for this activity.

Table 1: Results of survey of public opinion related with reclaimed water use.

No.	Contents of questionnaire*	Responses %	
		Yes	Not
1	User knows that green area irrigation is made with reclaimed water	86	14
2	User have had direct contact with reclaimed water, either accidentally or intentionally	69	31
3	User have had direct contact with plants which have been irrigated with reclaimed water	67	33
4	User have eaten food on irrigated areas with reclaimed water	31	69
5	User have drunk reclaimed water	2	98
6	User have seen at least one sign related to irrigation with reclaimed water	53	47
7	User sometimes, often or usually have perceived unpleasant odors near from irrigated areas	53	47
8	User have information about reclaimed water quality	0	100
9	User knows any guidelines or regulations for reclaimed water use	0	100

*Questionnaire applied to 49 users.

5 Conclusions

This preliminary investigation indicated that in general, the acceptance by users was encouraging for reuse wastewater in green areas irrigation; however, treated wastewater doesn't satisfy all the requirements for its use in sites with open access or public direct contact. Even though the experience of reclaimed water use has demonstrated the potential of recycled water to supplement fresh water reducing water supply costs, it's possible to visualize potential harmful risks on human health. This danger is related with the lack of controls on the distribution and use of the reclaimed water as well as the void of communication, education

and training related with management, storage, distribution, monitoring and reuse of reclaimed water requirements.

The development of an integrated water reuse management plan that ensures sustainability of water quality and quantity in the city of Chihuahua requires the following strategies:

a) To perform a global impact assessment considering the different environmental, economic and social factors involved in the actual practice of reclaimed water use. This strategy may begin with an inventory of all the activities related with production, storage, distribution and use of reclaimed water in the city.
b) Monitoring and realizing regular chemical and microbiological analyses which provide information about the wastewater treatment efficiency and the quality of reclaimed water in specific sites of application. It's interesting to evaluate parasites as Giardia and Cryptosporidium which occurrence in reclaimed water has been considered significant in recent years.
c) To release more specific guidelines or criteria which contribute to the protection of public health and the environment. These guidelines may consider the analyses of turbidity and a more strict level of disinfection related with Faecal Coliform bacteria concentration either for reuse of water where no public or worker contact is expected than in the case of uses where direct or indirect contact is likely or expected.

An important issue to consider in the proposed regulations is the minimum distance to protect drinking water supplies from contamination as well as to avoid human exposure with aerosols and windblown spray of reclaimed water that is not highly disinfected. Also may be considered the requirements to maintain the desired quality of reclaimed water when it is stored, preventing the degradation associated with algae growth and the odor production. Of particular importance is the establishment of public protection health measures like regulations to prevent cross connections, development of measures to identify the non potable components, prevention of improper use of reclaimed water through public information programs and the training of workers to be responsible for operation, maintenance and inspection of reclaimed water use system.

This paper gives an overview of the actual scheme of reuse of wastewater in the city of Chihuahua. The preliminary information is the basis to develop specific guidelines and strategies conducting to use best management practices in the planning, design, construction, operation and management of reclaimed and reuse system, to benefit the environment through and economic and ecologically sustainable scheme.

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References

[1] Medellín-Azuara, J., L. G. Mendoza-Espinosa, J. R. Lund and R. J. Ramírez-Acosta. The application of economic-engineering optimisation for water management in Ensenada, Baja California, Mexico. Water Science and Technology. Vol 55 No. 1-2 pp 339-347. 2007.
[2] UN. United Nations. Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 2002.
[3] Anderson, J. The environmental benefits of water recycling and reuse. Water Science and Technology: Water Supply. Vol. 3 No. 4 pp. 1 -10, 2003.
[4] CNA. Comisión Nacional del Agua. Determinación de la disponibilidad de agua subterránea en el Acuífero Chihuahua-Sacramento. Gerencia de Agua Subterránea. México, D. F. 2001.
[5] NOM-003. Norma Oficial Mexicana NOM-003-ECOL-1997 que establece los límites máximos permisibles de contaminantes para las aguas residuales tratadas que se reusen en servicios al público. Diario Oficial de la Federación, México, D. F. 21 de septiembre de 1998.
[6] U. S. Environmental Protection Agency. Guidelines for Water Reuse. U. S. Agency for International Development. Washington, DC. 2004.