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Review Article

Current Problems with Drinking-water Quality in Argentina

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Abstract

The quality of drinking water is a powerful environmental determinant of human health, and biological and/or chemical pollution can, therefore, have profound repercussions on the latter. The present paper reviews the available literature on contaminated sources of surface and groundwater in different parts of Argentina, analyzes the origins of contamination and investigates the linkages between contaminated water and prevalent diseases in the affected areas. The analysis concentrates on the groundwater consumed by inhabitants of Greater Buenos Aires, the vast urban area surrounding the city of Buenos Aires; and the surface water of the Rio de la Plata that supplies drinking water to Greater Buenos Aires and nearby urban areas such as La Plata, Ensenada and Berisso. The paper also analyzes the problem of arsenic pollution in groundwater.

Keywords: Water Quality; Cyanobacteria; Cyanotoxins; Arsenic; Human Health

Introduction

Contaminated drinking water can seriously affect human health and measures taken to improve the quality of the water are therefore of crucial importance. Access to quality water and sanitation are two of the basic pillars of public health and count among the best indicators of improvements in the quality of human life.

According to the 2010 population census in Argentina, 32.8 million of the country's inhabitants (83%) have access to drinking water through the mains network and 19.4 million (49%) are connected to a wastewater disposal system, an increase of 4% and 6%, respectively, over figures from the 2001 census)[1]. There is a disparity in coverage in the different regions of the country: Over 95% of households in 6 areas (Buenos Aires city, the provinces of Chubut, Jujuy, San Luis, Santa Cruz and Tierra del Fuego) are connected to mains water but in a further 5 provinces (Buenos Aires, Chaco, Formosa, Misiones and Santiago del Estero), only 80% are connected. In terms of sewage disposal, the figures are highly unequal: in the patagonian provinces (Santa Cruz, Rio Negro, and Neuquén) and the city of Buenos Aires close to 80% or more of the population are connected to a wastewater system, whereas in the provinces of Misiones, Santiago del Estero, Chaco, San Juan and Formosa less than 30% are connected.

It is important to consider drinking water and sanitation in conjunction since deficiencies in either or both services can have a negative impact on the environment and also pose a serious risk to human health. Microbial contamination of drinking water constitutes the most common and widespread risk to human health associated with water-borne diseases, and it is therefore essential that an adequate system be in place to control this type of pollution. Among the chemicals that adversely affect human health, when consumed in excessive amounts are fluoride, arsenic and nitrate [2,3].

This paper analyzes three water quality cases linked to human health problems in Argentina: case 1: bacteriological problems and excess nitrate in contaminated groundwater providing drinking water to the densely populated Greater Buenos Aires; case 2: the increasing eutrophication of the waters of the Rio de la Plata, the main source of drinking water serving the city of Buenos Aires and its surrounding urban areas, with the recurrent presence of toxigenic cyanobacterial blooms; and case 3: the problem of arsenic in the groundwater in various parts of the country.

The water in the urban areas surrounding the city of Buenos Aires

The urban areas surrounding the city of Buenos Aires, referred to by National Institute of Statistics and Census 2011[1] as districts of Greater Buenos Aires, comprise 24 municipalities and constitute one of the world's largest urban conglomerates, accounting for 30% of the country's population -over 10 million people- according to the 2010 National Population, Household and Housing Census [4]. Greater Buenos Aires is an example of non-programmed population growth giving rise to serious deficiencies in basic sanitation and exposing the inhabitants to numerous environmental risk factors.

According to the 2010 census, an average of only 75% of the population of the Province of Buenos Aires has access to mains water and less than half (48%) are connected to a sewerage system [1]. This means that more than three million people in the area have no connection to mains water and have to rely on groundwater and wells. In view of the serious pollution problems affecting groundwater sources both in urban and rural areas, the associated risks to human health are naturally of considerable concern.

The prevalence of water-borne diseases in Greater Buenos Aires was studied by Monteverde et al. [5]. These authors found that 11% of the population had suffered from diarrhea at least once during the previous year; 7% had suffered from gastroenteritis; 4% from intestinal infections; 4% had intestinal parasites; 3% had some kind of skin disorder; and 0.72% of the population was found to be affected by hepatitis A, a figure considered to be underestimated. Monteverde et al. [6] evaluated the link between water contamination and lack of basic sanitation services in the area and the probability of being affected by these diseases. They assessed 151 households where at least one member had been affected by a water-borne disease during the previous year. Water samples were collected from the tap in households served by mains water or from the wells used as a source of drinking water where there was no mains connection. Samples were taken from the water dispenser in those cases where this was the main source of drinking water. The results showed that the level of chemical (excess nitrate) or bacteriological (total coliforms, fecal bacteria and/or *E. coli*) pollutants in 44% of the samples rendered the water not fit for human consumption. 40% of the samples showed microbial contamination only (presence of coliforms and/or *E. coli*). It is important to take the origin of the samples into account in the analysis. The percentage of non-potable water samples by origin were: mains water (17%), water from a dispenser (45%) and well water (80%). *E.coli* and coliforms were present in mains waters (9%) dispenser water (45%) and well water (83%).

The non-potable samples of mains water (9%) were collected after the water had been stored in a tank or had passed through some type of filter, indicating that the cause of the contamination may have been a lack of proper maintenance of the storage tank or the filter. With respect to nitrate pollution, 8% of the samples from mains water showed to be non-potable because of high nitrate levels [6]. The main sources of pollution in water samples from wells were bacterial (coliforms and/or *E. coli*) and chemical (high nitrate levels). This points on the one hand to the deterioration of the water in the aquifer serving the population of the area, known as the Puelche Aquifer (see below), which historically provided good quality water and had a low level of vulnerability; and on the other hand it raises doubts about the efficacy of the insulation between contaminated and non-contaminated aquifers and the wells from which water is drawn. The bad quality of the drinking water in households with no access to a mains connection is a fundamental problem, the solution to which does not necessarily lie in the use of water from a dispenser since in half the cases analyzed, this water also proved to be unsafe for drinking. These findings underline the need to increase water quality controls and investigate the source of the dispenser water sold in the Greater Buenos Aires area. Monteverde et. al., [6] indicate that in most cases in which the dispenser samples were considered unsuitable for human consumption, the brand of the water was not identified, or if it was, it was a relatively unknown brand that did not state the origin of the water. The data on samples of good water showed that this source of water had a positive and statistically significant effect on the probability of contracting a water-borne disease such as diarrhea, intestinal infections, and dermatitis. For statistical analysis of the information, the final database was translated to a base Data in Stata / SE format (version 10.1) program. Finally, the authors estimated by regression models the effect dichotomous source and water quality on the probability of waterborne diseases, controlled by possible variables confusion (such as age, sex, and the low level educational). The results indicated that the likelihood of contracting gastroenteritis or intestinal parasites was higher than one but not statistically significant. Where wells were the main source of drinking water there was an 87% higher probability of contracting diarrhea and a 160% higher chance of contracting dermatitis [6]. The magnitude of the estimated probabilities indicates that members of households where wells are the main source of water have a 55% higher chance of suffering some water-borne disease than those living in households whose main source of drinking water is mains water [6]. The characteristics and changes occurring in the sources of water serving Greater Buenos Aires help to explain why a high proportion of households currently depend on sources of water considered unsafe for human consumption.

A review of the drinking water quality status in the Greater Buenos Aires area is informed by the company that provides water to the population [7]. The company indicates that it takes water supply is predominantly surface waters of the

Rio de la Plata and only 5%, corresponds to groundwater wells Puelche Aquifer. Water treatment plant processes an average of 4600000m3/day and corresponds to a population of 8,670,000 inhabitants served. The company reports that 99.7% of samples comply with the microbiological standards of potability of water and 99% of the samples agree with the physicochemical parameters analyzed. Among these, the most critical parameter corresponds to nitrates that can double in some cases the maximum allowed (45 mg/L). This is due to the high level of nitrate in groundwater wells exhibiting [7].

The groundwater in the Province of Buenos Aires consists of two main aquifers: the Pampean Aquifer, located approximately between 10 and 40 meters below sea level and the Puelche Aquifer, the main aquifer in the region, located between 40 and 70 meters below sea level. The Pampean Aquifer is the recharge source for the Puelche Aquifer and is the source of drinking water in peri-urban areas not connected to the mains water and where most of the wells lack insulated piping. This means that the samples from these wells are affected by domestically generated pollution (sceptic wells and lack of wastewater disposal) mainly in the form of coliform bacteria and *E. coli*.

The groundwater in the urban areas surrounding the city of Buenos Aires was also evaluated. In areas where the tap water does not reach, the population obtains water from groundwater by private wells. Water quality is related to the depth and maintenance of wells.

Memo et al [8] studied physical and chemical parameters of water from aquifer Puelche in areas nearby the city of Buenos Aires. They found average levels of nitrates of 34.4 mg/L ranging between 0.7- 157 mg/L; nitrite levels mean of 0.02 mg/L range (0-0.198 mg/L), phosphates mean value 0.05 mg/L and range (range 0- 0.273mg/L).

The University of Buenos Aires through a study group conducted a monitoring of the quality of water consumed by the population in areas of the Greater Buenos Aires taken from private wells. The results indicated that up to 50% of residential water wells were contaminated by fecal coliforms bacteria and *E. coli*, according to the season. *Pseudomonas aeruginosa* was detected in 18% to 50% of household wells tested according to the season. In addition, 40% of samples showed nitrates levels above the allowable limits while nitrites and ammonium levels did not exceed the limits allowed by Argentine Food Code [9].

As it can be seen a serious problem detected in samples of good water in the region of Greater Buenos Aires is contamination by nitrates. Auge et al. [10], reported nitrate levels in the Pampean Aquifer of between 1 and 202 mg.L^{-1}, averaging 43 mg.L^{-1}. In most cases, the levels exceed the limit of 45 mg.L^{-1} adopted by the Código Alimentario Argentino [11] (Argentine Food Code) as acceptable for drinking water. There is a higher concentration of nitrate in the Pampean Aquifer than in the Puelche Aquifer because since the former is more exposed to pollution from domestic (sceptic wells) and agricultural (fertilizers) sources.

Arellano and Zabala, [12] study the nitrate levels of the waters obtained from Puelches aquifer wells, captured at between 30 and 50 m, and informed nitrates levels high, with maximum values of 271mg/L. The authors indicate that sewage pollution and the existence of transport downward of the same accelerated by the existence of vertical hydraulic gradients increased by the bulges. Nor can exclude any preferential wastewater flows through the annular space of wells in areas affected by severe drawdowns because of bulges.

The Puelche Aquifer was the most intensively exploited Aquifer in Argentina until the mid-1990's, providing drinking water for a large part of the population of Greater Buenos Aires. This over-exploitation generated extensive depression cones giving rise to acceleration of vertical pollution by nitrates, metals, and hydrocarbons via the phreatic aquifer. As a consequence of this perturbation, numerous boreholes were taken out of service, making it necessary to substitute this source with treated waters from the Rio de la Plata [13]. The gradual increase in nitrate concentrations was a further reason for abandoning the boreholes accessing the Puelche Aquifer, whose degradation is a consequence of continuous direct and indirect anthropic intervention. Nitrate pollution is diffuse in urban areas and found at specific sites in rural areas. The urban contamination from rubbish tips, fertilizers, sceptic wells etc, has caused a marked deterioration in the quality of the water and made it necessary to mix the groundwater with that from the Rio de la Plata in order not to surpass the 45 mg.L^{-1} limit established by the Código Alimentario Argentino[11]. The high level of nitrates detected in the drinking water consumed by the local population, whether from wells or from mains water, is due to the lack of adequate monitoring of the aquifer to protect it from untreated wastewater, leaching from hazardous waste dumps, industrial effluents and agrochemical substances, and salinization from over-exploitation.

Surface water: the Rio de la Plata estuary

The Rio de la Plata estuary, situated at approximately 35ºS on the eastern coast of South America, is one of the largest estuaries in the world, with a total length of about 300 km. The total estuarine area covers around 35,000 km^2 and can be subdivided into two main zones: (a) the inner zone, comprising the area from the head down to the Punta Piedras– Montevideo cross-section, with a mean depth of about 5m; and (b) the outer zone, extending down to the conventional estuary limit at the Punta Rasa-Punta del Este cross-section, where the depth reaches 18 m.

Both in terms of water supply and recreational activities, the inner zone constitutes a valuable resource for the Buenos Aires Metropolitan Region, a densely populated area with more than 14 million inhabitants, and is traversed by a number of tributaries, the main ones being Lujan River, Matanza-Riachuelo River, Sarandi Creek, and Santo Domingo Creek [14].

Due to heavy urbanization, industrial settlement and port activities, the concentration of nutrients in the water has increased in the area near the drinking water intakes. Pizarro and Orlando [15] estimated that 25% of the nitrogen and phosphorous loads entered the upper region in 1980 via urban discharge, changing the eutrophic status of the system.

The total average discharge of the Rio de la Plata is approximately 25000 $m^3.s^{-1}$ but can be as low as 15000 m^3s^{-1} or as high as 50000 $m^3.s^{-1}$ during extreme events [16].

The numerous creeks, channels and smaller rivers along the coast of the Rio de la Plata are responsible for the total phosphorous and nitrogen content in the water as well as heavy metals, phytoplankton cells and pathogens [17]. Furthermore, the Rio de la Plata estuary is exposed to global climatic changes such as increases in air temperature, rainfall and fluvial flow, and the variability of the ENSO (El Niño-Southern Oscillation) phenomenon [18]. All these changes have become more evident over the past few decades, manifesting themselves in increasing trophic changes and the development of more frequent cyanobacterial blooms [19,20]. These blooms severely affect the biotic integrity of the estuary and disrupt its functioning as a potential source of water; furthermore, many cyanobacterial species produce a variety of toxic metabolites which can be harmful to both humans and animals [17].

This negative environmental impact on the Rio de la Plata implies a loss of phytoplankton diversity and favors the development of the dominant species, *M. aeruginosa*. Species of the genus Microcystis, (Order: Chroococcales) are known for their potential ability to synthesize toxins, mainly microcystins (MCs) [21]. Hepatotoxic microcystins (MCs) are the most frequently reported cyanotoxins in eutrophic freshwater bodies.

It is widely accepted that MC exposure occurs mainly by chronic oral intake of contaminated water and that it can produce liver damage [22]. Human exposure to MCs has been linked to high incidences of liver cancer in certain regions of China [23].

The first report on microcystin-containing blooms of *M. aeruginosa* along the coast of the Río de la Plata in Argentina was described by Andrinolo et al. [20]. Microcystin-LR (MC-LR) was found to be the major component of the bloom samples. These findings lead one to surmise that at certain times of the year, cyanobacterial blooms are produced in the reservoir and reach the water distribution network, thereafter being found in drinking water.

Health problems attributed to the presence of toxins in drinking water have been reported worldwide [24, 25]. Since the major route of human exposure to cyanobacterial toxins is via drinking water, it is crucial that water treatment systems eliminate cyanobacteria and their toxins. Conventional water treatment with only a filtration step [26] or with an additional flocculation step [27] has been shown to be ineffective in removing dissolved microcystins from the water. Flocculation with an appropriate concentration of flocculent is suitable only for removing cyanobacterial cells. However, the possibility of cell lysis could lead to an increase in extracellular toxin concentration, which cannot be eliminated by the above-mentioned methods. Furthermore, intact cells have been observed in water even after the treatment process [28].

Echenique et al. [29] studied the cyanobacterium *M. aeruginosa* in the coastal zone of the Rio de la Plata at Ensenada from December 2004 to April 2006 with the aim of evaluating the occurrence of cyanotoxins and their eventual presence in the main drinking water supply for La Plata and Ensenada cities close to Buenos Aires. During the study period, *M.s aeruginosa* was the predominant phytoplankton in the coastal waters, reaching values of 97% of the total. Total phytoplankton abundance was from 10,600 to 52,800 $cells.ml^{-1}$ with values for M. aeruginosa ranging between 7,560 and 51,000 $cells.ml^{-1}$. Microcystins were found in all samples collected from the river, the degree of toxicity fluctuating considerably between 400 and 6,800 $\mu g.gr^{-1}$ dry weight. In accordance with the guidelines produced by the World Health Organization [30,31], the degree of toxicity found in the algae and water of the study area constitutes a high risk factor, with levels exceeding the probability of 'moderate' adverse effects (20000-100000 $cells.ml^{-1}$) for most of the period.

Giannuzzi et al. [17] also analyzed water samples collected during 3 years (2004–2007) at three sampling sites along the coastal area of the Rio de la Plata estuary. Again, *M. aeruginosa* was found to be the predominant phytoplankton throughout the entire study period, exhibiting values from 0 to 458,400 $cells.mL^{-1}$. Total and fecal coliforms were present in high concentrations in all water samples, the values obtained ranging from 1500 to 4600 $MNP.100mL^{-1}$. The authors confirmed the presence of MC-LR in 90% of the samples that tested positive for microcystins. The MC-LR concentration at the different sampling sites showed values between 0.02 and $8.6\mu g.L^{-1}$. The WHO has established a provisional guide value of $1\mu gL^{-1}$ for MC concentrations in drinking water [30]. These authors detected the presence of microcystins in drinking water in 10 out of 13 samples at values from <0.1–7.8 $\mu g.L^{-1}$.

Microcystins released by *M. aeruginosa*, which develops under eutrophic conditions in the Rio de la Plata estuary, reach the mains water distribution network and attain concentrations that exceed the safe limit of 1 $\mu g.L^{-1}$ recommended by the WHO [30]. Water treatment in the Province of Buenos Aires involves coagulation, sedimentation, filtration (sand filter), and chlorination. An activated carbon step, which can adsorb and eliminate the toxin when cyanobacterial blooms or cyanotoxin levels similar to those reported in this study are observed, is seldom applied.

The high total cyanobacteria, *M. aeruginosa*, and total and fecal coliform counts reflect the existence of anthropogenic pollution in the Rio de la Plata estuary. Cyanobacteria also produce metabolites causing an unpleasant odor and taste in drinking water. Most of the odor and taste problems in drinking water are due to the microbial generation of volatile compounds, fundamentally geosmin and 2-methylisoborneol, whose odor is similar to that of moist earth or humidity. Their level of toxicity for humans is considered to be for the most part very low, though they do tend to generate breathing and digestive disorders in vulnerable people [31,32]. Offensive odor and taste in drinking water have been reported worldwide [24,25] and consumer perception of the quality of drinking water is typically influenced by these characteristics. The threshold for the detection of geosmin and 2-methylisoborneol in humans is markedly low (less than 10 ng.L^{-1}), so they can be easily perceived. Even though it has been suggested that the presence of such metabolites could be associated with the generation of cyanotoxins, a direct correlation between the two has not been established, not does the absence of odor necessarily indicate the non-existence of cyanobacteria in the water [31,33].

In view of these findings, it is evident that blooms of toxic strains of *M. aeruginosa* along the coast of the Rio de la Plata estuary in Argentina constitute an environmental and health hazard. The risk of human intake of microcystins is high due to the fact that conventional water treatment processes may not be sufficiently effective in removing them. The recurrence of this problematic phenomenon makes evident the need to incorporate new water-treatment systems capable of eliminating cyanotoxins and odorous metabolites and to reinforce monitoring programs to prevent the presence of MCs in drinking water. Particular attention should be paid to reducing the eutrophication of this water resource.

The problem of arsenic in groundwater

Another health problem in Argentina is related to the presence of arsenic in the water. Arsenic (As) contamination constitutes a serious health problem of global relevance owing to its carcenogenic and neurotoxic effects. Long-term exposure to arsenic can cause systemic health hazards including characteristic skin hyperpigmentation or depigmentation, hyperkeratosis on palms and soles, Bowen's disease, circulatory diseases, goiter, diabetes mellitus, cataracts, pterygium, neurological disorders, retarded mental development and cancers of the skin, lung, urinary tract, kidney, and liver. Chronic As poisoning, known as Chronic Endemic Regional Hydro arsenicism (C.E.R.H.A.), develops progressively and involves different organs and systems, most importantly the skin. One of the most serious consequences of C.E.R.H.A. is the development of neoplasias, mainly in the form of skin tumors [34].

Arsenic in Argentina is of natural volcanic origin or related to hydrothermal activity in the Andes mountain range. Secondary dispersion via surface water is mainly responsible for carrying the arsenic to the Atlantic coast. In several regions (the provinces of La Pampa, Córdoba, Tucumán, Chaco and San Juan), arsenic has been observed to co-exist along side other elements such as fluoride, vanadium, and boron. The long-term toxicological action of elements such as fluoride can potentiate the adverse effects of arsenic. In general, soft waters (poor in calcium and magnesium) and alkaline waters have the highest concentrations of arsenic.

In a vast area of Argentina known as the Chaco-Pampean Plain, covering around one million km^2 in the southeast of the Province of Cordoba, the Province of Santiago del Estero (mainly Monte Quemado and Urutaú), the provinces of San Luis, Tucumán, Chaco, Santa Fe, and part of the Province of Buenos Aires, aquifers can be found with As concentrations above 1000 µg.L^{-1}. The recommended upper limit set for drinking water by the WHO [35] and the Argentine Food Code is 10 µg.L^{-1}.

It is estimated that around 5.000.000 inhabitants of Argentina, i.e. 7% of the total population, live in areas where the water is polluted by arsenic. Furthermore, in 43% of the affected areas, the basic water requirements of 30% of the population are not met. Aboriginal communities and disperse rural populations are the most affected [36].

High levels of arsenic in groundwater have been reported in several areas throughout Argentina, particularly in the Puna region in the Andes, the Chaco region, Córdoba, and the Pampean Plain [37-40]. Concentrations of arsenic as high as 3000 µg.L^{-1} were recorded in groundwater in la Francia, a rural settlement in the Province of Córdoba, and up to 600 µg.L^{-1} on the Pampean Plain [37]. It has been reported that the number of locations with elevated levels of naturally occurring arsenic in water continues to grow. In addition, food may contain elevated arsenic concentrations [41-43]. In some areas such as the Puna and Chaco Salteño regions in Northern Argentina, arsenic concentrations were 20 times higher than the WHO's drinking-water standard of 10 µg.L^{-1}. The highest concentrations were found in San Antonio de los Cobres, Taco Pozo, and Anta, with a total population of about 14,000 inhabitans [44].

In collaboration with various institutions, Villamil Lepore and Garcia [36] undertook an epidemiological study of C.E.R.H.A. in Argentina on the basis of which they were able to draw up maps of hydroarcenisim throughout the country. A large percentage of the population in one of the study areas (Province of Santiago del Estero) was found to be highly exposed to arsenic via drinking water and food preparations involving the use of water, as corroborated by urine samples with high arsenic content. The presence of inorganic arsenic in food and water in these areas gives rise to arsenic concentrations in children several times higher than those in areas where the children consume water with less arsenic content. In terms of clinical manifestations, 14% of patients showed C.E.R.H.A.; it should be noted that these same manifestations were detected in children below 15 years of age. The authors conclude that the size and representativeness of the samples are not sufficient for extrapolation of the findings to other areas and they consequently underline the need to carry out a more in-depth epidemiological study at the national and local level.

The National Sanitary Regulatory Authority in Argentina (Ente Regulador de Servicios Sanitario) reports the prevalence of C.E.R.H.A. in 2% of the adult population studied in the Province of Santa Fe [45].

Navoni et al. [46] studied arsenic concentrations in drinking water collected in various localities of the Province of Buenos Aires and analyzed their epidemiological relationship with susceptibility factors and associated pathologies. Their findings show a wide range of concentrations from 0.3 to 187 $\mu g.L^{-1}$, with an average of 40 $\mu g.L^{-1}$. They reported maximum values 18-fold higher than those recommended by the WHO (10 $\mu g.L^{-1}$). 82% of the samples presented higher arsenic levels than the recommended limit of 10 $\mu g.L^{-1}$ and more than half of these were samples from mains water. One of the analyzed factors was the provision of water through the mains distribution. The inhabitants of most of the study areas obtained their drinking water from groundwater sources. The high level of arsenic present in these samples indicates a failure to monitor the water for its fitness for human consumption and it appears that the local population is exposed to a similar level of arsenic poisoning whatever the source of drinking water. It is therefore not only those living in dispersed rural settlements who are potentially at risk from arsenic poisoning, as already referred to in the literature, but also those living in urban centers.

The average mortality (deaths/100000 inhabitants) from tumors in the study areas was higher in men than in women. The respective figures for tumors in the respiratory tract were 310 vs 76, in the urinary tract 44 vs 11 and in skin, 21 vs 11. The appearance of malign arsenic-related skin neoplasias has been taken as an early warning sign of the possible subsequent development of internal organ cancers, as well as being the most cited tumors in the literature [47]. Arsenic metabolism is gender-related, affecting the degree of carcinogenicity induced by this element [48]. Women have a more efficient methylation profile (higher proportion of demethylated species) and are more easily able to eliminate the incorporated arsenic [49]. The literature reports a lower rate of arsenic-related cancers in women [50-52]. These studies found that mortality among populations in areas at risk of exposure to arsenic is 3-4 times higher for all types of tumor than among those who live in areas that are not considered to be exposed to arsenic-related health risks.

The US National Research Council has estimated that the additional cancer risk associated with lifetime exposure to arsenic at the new US arsenic drinking-water standard of 10 $\mu g.L^{-1}$ may be approximately 1 in 300 [53]. The risk may be even greater in susceptible subpopulations. Concha et al. [44] evaluated the spatial, temporal and inter-individual variations in exposure to arsenic via drinking water in Northern Argentina, based on measurements of arsenic in water, urine and hair. Arsenic concentrations in drinking water varied markedly among locations, from <1 to about 200 $\mu g.L^{-1}$. Over a 10-year period, the level of arsenic in water from the same source in the town of San Antonio de los Cobres in the Province of Salta fluctuated between 140 and 220 $\mu g.L^{-1}$, with no sign of a decreasing trend. Arsenic concentrations in women's urine (3–900 $\mu g.L^{-1}$) were highly correlated with concentrations in the water on a group level but showed marked variations between individuals. Arsenic concentrations in hair (20–1,500 $\mu g.kg^{-1}$) correlated poorly with urinary arsenic, possibly due to external contamination. A strong correlation between the concentrations of arsenic in urine and drinking water was observed, demonstrating the suitability of urine as a biomarker of arsenic exposure. The low consumption of beverages other than local drinking water in the studied groups is likely to have contributed to the strong correlation. The high intake of local arsenic-rich water also resulted in high arsenic concentrations in urine compared to water. Thus, arsenic concentration in urine seems to be a better biomarker of individual arsenic exposure than concentrations in drinking water and hair.

The literature reveals a linkage between arsenic-related deaths and arsenic levels in drinking water (higher than 50 $\mu g.L^{-1}$). However, scant information is available on morbimortality as related to the chronic effects of arsenic in the water whether at the provincial or national level in Argentina. This highlights a serious weakness in programs aimed at monitoring environmental pathologies and the need to put adequate controls in place. Unlike findings in studies from other countries, physical examination reveals no peripheral vascular signs or symptoms associated with chronic exposure to arsenic in Argentina, thus supporting the hypothesis that the manifestations of arsenic in Argentina are different and specific to the country. C.E.R.H.A. is a preventable disease.

It is the responsibility of public authorities worldwide to provide the population with safe drinking water. To this end, it is necessary to continue developing health education programs to diminish exposure to arsenic and to raise awareness about more healthy life styles among the local communities at risk.

Lowering the permitted level of As in drinking water in line with international standards is already a significant step in the right direction; however, there are still extensive areas in Argentina where the level of As in the groundwater is higher than the accepted standard and given that many of the inhabitants of these areas use the water to drink. The government needs to reinforce efforts to protect the population in these areas, especially children, who are particularly vulnerable to the effects of toxic substances.

Conclusion

The quality of drinking water of Argentina is variable according to the different regions of the country. The Rio de la Plata has, for decades, a major contamination emptying of industrial and household waste on its banks and in its tributaries. It also influences the drained water with chemicals, whose use in the field has increased sharply in the region in recent years contributing to the eutrophication of the river which has led to an increase in toxigenic cyanobacteria blooms. Groundwater in the area of Greater Buenos Aires predominantly present levels of nitrates exceeding maximum allowable as well. Microbial contamination type (presence of *Escherichia coli* and *Pseudomonas aeruginosa*) are frequently found in the Pampean Aquifer, located approximately between 10 and 40 meters below sea level. The problem of arsenic in groundwater affects the great extension of the country with levels very superiors to the allowed maximum values in the center of the country. Therefore water treatment plants, governments, and control agencies should reinforce efforts to protect the population especially children who are particularly susceptible to toxic substances.

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