



Presence of pesticides, mercury and trihalomethanes in the water supply systems of Ibagué, Colombia: threats to human health

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ABSTRACT

Chemical contamination of the water supply system caused by anthropic activities can cause adverse health effects. This study determined the presence of toxic metals, organic substances, pesticides and trihalomethanes in the water supply systems of the urban area of Ibagué City. The economic and sanitary activities located in the 25 surface streams of the 32 water supply systems of the municipality were characterized. A total of 25 water samples were taken from the surface streams, and 35 samples in the water network of each drinking water service provider for the identification of pesticides (carbamates, organochlorines, organophosphorus), mercury, arsenic, cyanide, lead, cadmium, antimony, cobalt, selenium, silver, nickel and hydrocarbons. The presence of trihalomethanes was sampled after the treatment process given. A total of 775 economic and sanitary activities were detected in the surface streams of the water supply systems, highlighting the human settlements, agricultural and tourist activities impact on the water sources. Organochlorine pesticides (0.009-0.109 mg/L), mercury (0.001-0.004 mg/L) were identified in the water supply system in concentrations higher than those permitted by local regulation. Concentrations of trihalomethanes (0.064-1.260 mg/L) were detected in 68.7% of the water supply systems with treatment. The presence of chemical contaminants occurs mainly in communities with water supply systems of low complexity with high anthropic affectation. It is necessary to strengthen the assessment of hazards and risk by health surveillance, as well as intersectoral intervention for the protection of water sources and the improvement of water treatment technologies.

Keywords: environmental health, mercury, pesticides, trihalomethanes, water contamination.

Presença de pesticidas, mercúrio e trihalometanos na água para consumo humano em Ibagué, Colômbia: ameaças à saúde humana

RESUMO

A contaminação química do abastecimento da água causada por atividades antrópicas pode causar efeitos adversos à saúde. O presente estudo propõe determinar a presença de metais



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tóxicos, substâncias orgânicas, pesticidas e trihalometanos dos sistemas de abastecimento da cidade de Ibagué, Colômbia. Foram caracterizadas as atividades econômicas e sanitárias presentes em 25 fontes de água superficial de 32 sistemas de abastecimento de água da área urbana do município. Se coletaram 25 amostras de água das fontes superficiais de água e 35 amostras do sistema de abastecimento de água para identificação de pesticidas (carbamatos, organoclorados, organofosforados), mercúrio, arsênico, cianeto, chumbo, cádmio, antimônio, cobalto, selênio, prata, níquel e hidrocarbonetos. A presença de trihalometanos foi avaliada no pós-tratamento. No total, 775 atividades econômicas e sanitárias foram detectadas nas fontes de água superficial do sistema de abastecimento de água, destacando o impacto dos assentamentos humanos, das atividades agrícolas e turísticas nas fontes de água. Pesticidas organoclorados (0,009-0,109 mg / L), mercúrio (0,001-0,004 mg / L) foram identificados no sistema de abastecimento de água em concentrações superiores às permitidas pelos regulamentos. Concentrações de trihalometanos (0,064-1,260 mg / L) foram detectadas em 68,7% do sistema de abastecimento de água com tratamento. A presença de contaminantes químicos ocorre principalmente no abastecimento de água comunitária de baixa complexidade com alta afetação antrópica. É necessário fortalecer a avaliação de perigos e riscos pela vigilância sanitária, bem como a intervenção intersetorial para a proteção de fontes de água e o aprimoramento das tecnologias de tratamento de água.

Palavras-chave: contaminação da água, mercúrio, pesticidas, saúde ambiental, trihalometanos.

1. INTRODUCTION

Water quality is an essential component of public health. Chemical contamination of water sources is increasing; 30% of sweet water is used by industry and municipalities, generating large areas of highly contaminated wastewater. Anthropogenic activities, such as industry, agriculture, and discharge of large amounts of organic and inorganic toxic fuels, increase the health risks associated with these substances (Schwarzenbach *et al.*, 2010, Fawell and Nieuwenhuijsen, 2003). Industrial pollutants intensify the contamination of water systems because treatments that control infectious agents are not effective in removing many toxic chemicals from drinking water (Landrigan, 2018).

In Colombia, the quality of water supply is regulated by Decree No. 1575/2007 and Resolution No. 2115/2007 (Colombia, 2007). In routine surveillance, some chemical substances are monitored, among them: zinc, calcium, phosphates, manganese, molybdenum, sulfates, chlorides, iron, aluminum, calcium, fluorides, nitrites, nitrates and magnesium. However, toxic chemicals, such as pesticides, mercury, arsenic, cyanide, lead, cadmium, antimony, cobalt, selenium and silver, are not routinely monitored by Colombian sanitary surveillance. In these cases, the toxic chemical substances are subject to surveillance if anthropic activities associated with the release of these substances are identified in water sources of the water supply system and their presence confirmed in the water supply according to Resolution No. 4716/ 2010 (Colombia, 2010).

The increase in local agriculture, industry, mining, and increasing urbanization in Colombia implies an increase in potentially toxic substances in the water. An evaluation of the progress towards the goals for drinking water access of the Millennium Development Goals (MDGs) for Colombia shows a level of partial compliance with the established goals. By 1990, 88% of the total population had safe water sources, distributed in 97% of the urban population and 69% of the population in the rural areas, for which a goal of 99.2% and 78.1% respectively was established. By 2014, 91% of the population had access to safe water sources, 97% in urban areas and rising to 74% in rural areas, evidencing enormous inequities in the provision of the public service of safe water between these sectors, as well as critical territorial gaps that deserve

priority attention (UN, 2015).

It is essential to understand that safe sources of water are defined as connections to the water supply, pipe, well, pump, bottled water, tank car, and public battery. In this definition, there is no emphasis on the evaluation of potability standards. Therefore, many safe water sources must be monitored for quality to determine their true impact on health.

The monitoring of water quality carried out in 1,067 municipalities (96.8%) of Colombia in 2014 pointed out the problems of water quality, considering that only 195 (18.3%) met the standards established by the Colombian regulations presenting an acceptable IRCA (Water Quality Risk Index) of 502 (47%) within the partial compliance range, and 370 (34.7%) did not comply with the established standards (Guzman *et al.*, 2015). The present study evaluated the presence of toxic metals, organic substances, pesticides and trihalomethanes in the water supply system of the urban area of the municipality of Ibagué, Colombia, considering the sanitary surveillance guidelines established in Resolution No. 4716/ 2010 in order to discuss its contributions and challenges.

2. METHODOLOGY

2.1. Study area

The study was conducted in the city of Ibagué located in the center-west of Colombia, on the central mountain range coordinates 4°26'16" N, 75°12'02" W at an altitude of 1,285 meters above sea level, with average annual total rainfall of 1,691 mm, and temperatures between 20° and 28°C (IDEAM, 2017). The city has a territorial extension of 1,439 km², administratively divided in 13 communes in the urban area and 17 rural settlements, with a total of 558,805 inhabitants according to projections of the National Administrative Department of Statistics - DANE 2018 (Colombia, 2011). It has a total of 32 water supply systems in the urban area. The municipal water supply and sewerage service company serves 80% of the population, and 31 low complexity community-type water supplies, which serve 20% of the population in those sites of difficult access; only 16 water supplies have treatment plants built and operating. The water supply consists of 25 surface water sources that belong to the basins of Rio Totare, Rio Coello and Rio Opia.

2.2. Characterization of economic and sanitary activities in water sources

The activities that affect the quality of the surface water source of the water supply system were identified, for which a survey was carried out with the environmental authorities and the water supply service companies. Subsequently, a characterization of the economic and sanitary activities present upstream of the intake was carried out through field visits by inspectors. To this purpose, a technical sheet was prepared which allowed the gathering of the economic and sanitary information of the water source: type of activities, coordinates, possibly associated chemical inputs, and occasional discharges. The characterization of the activities was carried out between September and December of 2017. During this period three trips were made through the water basin: one through the main channel of the basin and two through routes by the water dividing lines that delimit each basin (left and right limits of the basin), trying to cover the greatest of area. Subsequently, technical sheets were completed, and the activities were georeferenced using Trimble GPS equipment SPS780 with a TSC2.SC.900 antenna. The information collected was systematized, and the coordinates were graphically mapped within the geodetic network of the Instituto Geográfico Agustín Codazzi-GAC using ArcGis software with its Arsmap 10.5 application.

2.3. Sampling

A total of 60 water samples were taken: 25 samples, one in each surface water source of the pump intake, and 35 starting points of the distribution networks of the water supply system.

Four samples of the municipal water supply were taken due to the population served, and one sample for the communal water supply. The sampling was carried out in December 2017, following the guidelines for taking and presenting samples (APHA *et al.*, 2005; Instituto Nacional de Salud, 2011), considering the specifications of each characteristic (see Table 1). The temperature and pH were measured in the samples taken. The reading of the free residual chlorine was included in the treated samples. The samples were then stored in refrigerators to keep them at temperatures from 2°C to 4°C, to be transported to the reference laboratory in Bogotá DC, considering the chain of custody, biosecurity measures and preservation conditions for transportation in order to guarantee the integrity of the sample.

Table 1. Preservation of the samples.

COMPOUND	PRESERVATION
Arsenic, cadmium, mercury, nickel, silver, lead, selenium, antimony, cobalt, carbamate	HNO ₃ was added until pH <2 was obtained and cooled to ≤ 6°C
Hydrocarbons	Addition of HCl or H ₂ SO ₄ until pH ≤ 2, Refrigerate at ≤ 6°C
Free cyanide	NaOH until pH ≤ 12. Refrigerate at ≤ 6°C
Organochlorine pesticides	Refrigerate at 4°C to 6°C. If additional chlorine is present (sodium thiosulfate 0,92 mL at 10%), adjust pH from 5 to 8 with either NaOH or H ₂ SO ₄
Organophosphorus pesticides	Refrigerate at 4°C to 6°C. Adjust pH from 5 to 8 with either NaOH or H ₂ SO ₄
Trihalomethanes	Cool to ≤ 2°C

2.4. Laboratory analysis

The samples were processed in the Laboratory of Analysis of Water and Soils of Colombia ANASCOL S.A.S., a laboratory accredited by the Institute of Hydrology, Meteorology and Environmental Studies - IDEAM and the Interlaboratory Program of Quality Control of Drinking Waters -PICCAP. The parameters were analyzed in both raw and treated water; trihalomethanes were only analyzed in treated water (see Table 2). The methodologies for analyzing the selected characteristics were carried out according to the guidelines of the "Standard Methods for the Examination of Water and Wastewater," Edition 21 (21). The samples were processed in December 2017 and January 2018. The minimum values detectable by the techniques used are presented in Table 2; the results obtained were evaluated considering the minimum values acceptable by the resolution N° 2115/2007 of Colombia. The analysis of the presence of contaminants was carried out for the treated water supply systems and is not treated separately, considering the samples in the surface water source and in the supply network.

Table 2. Analytical characteristics and methodology for the analysis of the chemical water quality of the urban water supply of Ibagué, Colombia, 2017.

VARIABLE	METHOD	MDV * (mg/L)	MVA ** (mg/L)
TOXIC METAL			
Arsenic	Atomic Absorption Spectrophotometry - Manual hydride generation. SM3114B	0.01	0.01
Cadmium	Digestion Nitric Acid-SM 3030 E-Atomic Absorption Spectrophotometry direct flame Air-Acetylene. SM 3111B	0.001	0.003
Mercury	Atomic Absorption Spectrophotometry - Cold Vapor. SM3112B	0.001	0.001
Nickel	Digestion Nitric Acid-SM 3030 E-Atomic Absorption Spectrophotometry direct flame Air-Acetylene. SM 3111B	0.005	0.02
Silver	Nitric Acid Digestion-SM 3030 E- Atomic Absorption Spectrophotometry direct flame Air-Acetylene. SM 3111B	0.02	NR
Lead	Nitric Acid Digestion-SM 3030 E- Atomic Absorption Spectrophotometry direct flame Air-Acetylene. SM 3111B	0.005	0.01
Selenium	Atomic Absorption Spectrophotometry - Manual hydride generation. SM3114B	0.0005	0.01
Antimony	Digestion Nitric Acid-SM 3030 E-Atomic Absorption Spectrophotometry direct flame Air-Acetylene. SM 3111B	0.3	0.02
Cobalt	SM 3030 E SM 3113 B Digestion - AA - Graphite Oven (Electrothermal)	0.001	NR
ORGANIC SUBSTANCES			
Dissociable cyanide	Distillation - Volumetric. SM 4500CN - A. B. C. D. I	0.4	0.05
Hydrocarbons	Partition - Infrared / Determination Hydrocarbons. NTC 3362: 2011-11-30 Numeral 4. Method C / Numeral 7. Modified Method F.	1	0.01
PESTICIDES			
Carbamates	China National Standard Method GB / T 5009.104-2003 Liquid-liquid extraction, CG / NPD	0.01	0.0001
Organochlorine pesticides	Liquid-Liquid Extraction. EPA 3510 C. Revision 3. December 1996- Gas Chromatography with Electron Capture Detector (GC / ECD). EPA 8081B. Revision 2. February 2007	0.005	0.0001
Organophosphorus pesticides	Liquid Liquid Extraction US-EPA 3510C Revision 3. December 1996-Gas chromatography with Nitrogen-Phosphorus detector (GC / NPD). US-EPA 8141B Revision 2. February 2007.	0.0025	0.0001
DISINFECTION SUB-PRODUCTS			
Trihalomethanes	SM 6232B Gas chromatography with electron capture detector (GC / EDC). US-EPA 8081 B. Revision 2. February 2007.	0.004	0.2

*MDV: Minimum Detectable Value

**MVA: Acceptable Maximum Value according to Resolution N° 2115/2007 of Colombia.

3. RESULTS AND DISCUSSION

The laboratory results identified the presence of cadmium, mercury, and nickel in water sources and the supply network of some water supply at the established detectable concentrations. No arsenic, barium, molybdenum, silver, lead, selenium, molybdenum, cobalt, hexavalent chromium, surfactants, dissociable cyanide, hydrocarbons, carbamates and

organophosphorus pesticides were detected. The reference values for cadmium, nickel and antimony were below the VMA levels established by Colombia (see Table 3).

Table 3. Results of the chemical analyses in water sources and supply network of the water supply system of the urban area of Ibagué, 2017.

Characteristic	UNI ¹	MVA COL ²	Results (Min - Max)		Water supply system with presence of the Characteristic		Water supply system above MVA COL		
			WS ³	SN ⁴	WS	SN	WS	SN	
Cadmium	mg/L	0.003	0.0015	0.0016	0.001-0.001	3	10	0	0
Mercury	mg/L	0.001	0.001	0.003	0.001-0.004	9	11	9	11
Nickel	mg/L	0.02	0.005	0.007	0.005-0.007	11	11	0	0
Antimony	mg/L	0.02	0.005	0.03		1	0	0	0
Total Organochlorines	mg/L	0.001	0.018	0.056	0.009-0.109	22	13	22	13
Alpha-BHC	mg/L	0.0001	0.01	0.101	0.025-0.101	1	4	1	4
Heptachlor	mg/L	0.0001	ND ⁵	0.022		0	1	0	1
Aldrin	mg/L	0.0001	0.014	0.040	0.075-0.064	16	9	16	9
Heptachlor epoxide	mg/L	0.0001	ND	0.012	0.007-0.012	0	2	0	2
Endosulfan sulfate	mg/L	0.0001	0.005	0.020	0.005-0.008	15	2	15	2
Total Trihalomethanes	mg/L	0.2	NA ⁶	1.260	0.064-1.260	NA	15	NA	11
Chloroform	mg/L	0.2	NA	0.068	0.003-0.068	NA	14	NA	0
Bromodichloro Methane	mg/L	0.2	NA	0.028	0.003-0.028	NA	10	NA	0
Dibromochlor Methane	mg/L	0.2	NA	0.074	0.058-0.074	NA	15	NA	10

¹ UNI: Units ² MVA COL: Acceptable Maximum Value Colombia, ³ WS: Water source, ⁴Supply network, ⁵NR: No Report, ⁶NA: Does not apply.

The analysis showed the presence of mercury mainly in community-type water supplies. Mercury is found in the environment in its inorganic and organic forms. Its inorganic form is present in surface and underground waters; mercury is transformed to methylmercury that enters the human body through ingestion (Díaz-Arriaga, 2014). It mainly affects the nervous and immune system, the digestive system, skin and lungs, kidneys and eyes. Children are vulnerable to mercury poisoning, which can lead to deterioration of the developing central nervous system, as well as lung and nephrotic damage (Bose-O'Reilly *et al.*, 2010; Counter and Buchanan, 2004).

The presence of mercury is a critical problem in public and environmental health in Colombia, due to the high exploitation of gold. More than 17 departments and 80 municipalities in the country are affected by gold mining (Díaz-Arriaga, 2014). Mercury has been identified in water sources in several regions of the country, such as the Ciénaga de Ayapel and the waters of the Cai River in the department of Chocó, as well as in the Ciénaga de Grande Achi in the department of Bolívar (Díaz-Arriaga, 2014; Marrugo-Negrete, 2015). Likewise, in the region of La Mojana, the presence of mercury in biological samples of mining workers was evidenced, establishing a statistical correlation with water sources as a source of contamination (Díaz *et al.*, 2018).

The analysis of pesticides evidenced the presence of organochlorines in the water source of 22 water supplies (68.7%) and the supply network of 13 water supplies (40.6%). The organochlorines identified were Alpha-BHC, heptachlor, aldrin, heptachlor epoxide and endosulfan sulfate, but carbamates and organophosphates were not identified. The values detected in both water sources and in the supply network were above the reference VMA. Organophosphates, organochlorines, carbamates and pyrethroids are among the most

commonly used pesticides. Organochlorine compounds can resist biodegradation, accumulate in the environment and become persistent organic pollutants that have been detected in animal and human tissues. It can have adverse effects on the endocrine system affecting the production of hormones, such as thyroid and sex hormones; in the nervous system it can cause neuronal effects and dysfunction of neurotransmitters and affect liver function besides being potentially mutagenic and carcinogenic (Hendry-Hofer *et al.*, 2019; Nicolopoulou-Stamati, *et al.*, 2016; Zaragoza-Bastida *et al.*, 2016).

Pesticides have been widely identified in water sources in Colombia. At the Ciénaga de Grande de Lorica in the department of Córdoba, α -BCH, β -BCH and γ -BCH, aldrin and heptachlor epoxide organochlorines were identified which exceeded the individual concentration of pesticides allowed by the national regulations (Lans *et al.*, 2008). An analysis of exposure to pesticides of the inhabitants of the riverside of the Bogotá River evidenced the presence of organochlorine and organophosphorus pesticides in the river water and fish, and ethylenethiourea in human biological samples (0: in biological samples of human origin) (Monsalve *et al.*, 2012).

With respect to water supply consumption, a study was carried out in Soacha (department of Cundinamarca) which analyzed the presence of mercury and organophosphorus and carbamate pesticide residues, identifying values below the Acceptable Maximum Values (VMA) (Silva *et al.*, 2015). In Cali, an analysis of mercury, diuron and 2,4 diclofenac acetic acid in the city's water supply concluded that these substances were absent (Echeverry *et al.*, 2015). The water supply systems mentioned are highly complex; the water supplies analyzed in the present study presented highly dangerous pollutants, mainly in the community water supply system, evidencing the problems of this type of system. To fulfill the goals of the SDGs (Sustainable Development Goals), it is necessary to define public policies and investments that strengthen the community treatment systems of the water supply with sustainable alternative solutions that recognize their technical-administrative nature for reaching the goals of water safety for the country.

The presence of trihalomethanes was identified in the water supply of 15 of the 16 water supplies with treatment. Chloroform, bromodichloromethane and dibromochloromethane were analyzed in 11 water supplies (68.7%) with detected values above the VMA. Trihalomethanes are byproducts derived from the oxidation of organic matter in chlorination; they have been associated with alterations of the liver, kidney, nervous and reproductive system, showing carcinogenic and mutagenic effects (Kim *et al.*, 2017; Sanchez, 2008). Through the analysis of trihalomethanes, values higher than those established in the regulations were identified in 68.7% of the water supplies with treatment, including conventional and communal-type water supply. In the municipality of Pereira, the presence of trihalomethanes in 75 water samples was evaluated in the water supply of the company Aguas y Aguas de Pereira, concluding that all samples showed results within the VMA established by the regulations (Vargas *et al.*, 2015). The rate and the degree of formation of the trihalomethanes may increase depending on the concentration of chlorine and humic acids, the temperature, the pH and the concentration of bromide ion (WHO, 2017). The World Health Organization (WHO) recommends implementing basic strategies to reduce the concentration of trihalomethanes, such as: (a) changing process conditions (including the elimination of precursor compounds prior to the application of the disinfectant); (b) changing the disinfectant to one less prone to produce by-products in the water source; (c) use non-chemical disinfection methods; (d) eliminate them before water distribution (WHO, 2017).

In the field visits by inspectors, 29 wastewater sources were identified that flow directly into 13 water sources of 19 water supplies, 96.5% of which were derived from human settlements and 3.5% from agricultural activities. In the characterization of the economic and sanitary activities upstream of the intake, a total of 775 activities were identified on the margin

of the streams of the water supply. The source with the highest number of activities was the River Combeima with 19.4% (source of a water supply), followed by La Volcana Stream with 9.82% (source of one water supply), El Tejar Stream with 8.07% (source of one water supply) and La Granate Stream with 5.14% (source of three water supply).

The economic and sanitary activities identified are due to human settlements (53.1%), agricultural activities (42.5%), sand and clay extraction (1.9%), tourism (1.7%) and construction (0, 8%). The most significant activity was human settlements associated with the increase in population and urbanization in the peripheries, where the sources of the water supply are located. A highly diversified agricultural and livestock exploitation was observed: coffee, plantain, cocoa, kidney bean, banana, lulo (Quito orange), blackberry, corn, beans, avocado, vegetables, cassava and orange, poultry, pig, livestock, pisciculture and horse stalls, many of which are on the margin of the ravine without any delimitation. Likewise, the study identified 63 forested areas and 17 disaster zones.

There was no direct relationship between the number of economic and sanitary activities present at the water source with the presence of contaminants in the drinking water. In systems with conventional treatments, the contaminants were not identified, while in community systems that were supplied by surface sources with high percentage supply systems with contaminants and others without water contaminants were identified. It is crucial to prioritize the protection of water sources, especially in those cases not having efficient treatment. The WHO, through the Water Safety Plan, recommends monitoring the sources continuously by service providers. Knowing the nature of the quality of the raw water, the dynamics of the water sources, the changes related to weather phenomena or other circumstances, including runoff or recharge processes, as well as verifying and correcting land use in the catchment basin, is required in order to carry out risk management at the water sources of the water supply.

In the monitoring of the water quality in terms of the chemical pollutants studied, there are significant limitations that must be overcome in order to be able to evaluate more rigorously the risks to health derived from those chemicals that are considered in the regulations. These include the analysis of health effects associated with such chemicals, considering the frequency of exposure and the concentrations at which the population will be exposed. The likelihood of health effects depends on toxicity and concentration, but also depends on the period of exposure, since for most chemicals, health impacts are associated with long-term exposure (UN, 1999).

The regulations establish that the definition of the characteristics that must be analyzed in the water source and the water supply is determined from the field visits by inspectors; 29 wastewater sources were identified that flow directly into 13 water sources of 19 water supplies of the economic and sanitary activities upstream of the intake. It is essential to mention that there are difficulties in performing exhaustive field visits by inspectors, considering the geographical adversity and the runoff potential of the leachate, adding a significant margin of error. Subsequently, the sampling established for the identification of these pollutants in the water source and the distribution network is annual or semi-annual, depending on the population served, sampling that is not quite representative, knowing the dynamics of the basins of the water sources. The definition of the characteristics monitored in the supply network is taken from the sampling, and the results of the first sample carried out in the water source which, as mentioned, is poorly representative, being that the definition of contaminants in the network will be subjective. In this study, we detected contaminants present in the water supply and not in the water source, as well as mining contaminants without their prior identification in the field visits by inspectors.

Another important aspect is the analytical availability in the territories; it is crucial to consider that the analysis of these parameters is recent in the regulations and the methodologies present high costs. Many of the territories do not have an adequate laboratory setup for testing

these substances and few laboratories in the national public health network have implemented these methodologies. On the other hand, the methodologies available in some cases are not able to identify low concentrations of the substance analyzed. Therefore, laboratories require strengthening of their infrastructure and laboratory techniques, as well as their measurement and calibration capabilities.

Finally, the VMA for pesticides in the Colombian regulations are not specific for each of the chemical groups, which makes its analysis cumbersome. A general value is established for all pesticides, without considering that each one in the groups presents a particular mechanism of action and established lethal dose. It is essential, then, to develop regulations relating to the analysis of pesticides in water in Colombia. The regulations in the legal frameworks of Brazil, Chile, Uruguay and Venezuela follow the guidelines of WHO, where there are specifications for each chemical group of pesticides (Pinto *et al.*, 2012).

4. CONCLUSIONS

This study identified the presence of contaminants such as mercury, pesticides and trihalomethanes in water of urban supply systems, showing the weaknesses of the treatment system in eliminating these high risk chemical substances. It is observed that some supply systems with “safe sources” have chemical contamination, which makes it essential to determine the real risk to the populations served by these systems, considering the presence of water contaminants.

The results show the lack of protection of the hydraulic sources of urban aqueducts, associated with the presence of economic and sanitary activities and discharges from settlements, agriculture, mining, tourism and construction that increase the pollution load of the sources. It is therefore necessary to strengthen the monitoring of water sources and to promote the timely management of hazards at the sources.

It is also important to strengthen the analysis of chemical substances and the evaluation of hazards and risk by the health authorities. Water quality monitoring should opt for new, more representative and accurate tools to assess the quality of drinking water and its impacts on health.

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