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Hydrocarbon water-pollution related to chronic kidney disease in Tierra Blanca, a perfect storm

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ABSTRACT

Chronic kidney disease (CKD) affects the kidneys, and in severe cases is considered as end-stage renal disease which can only be treated by dialysis and transplantation. Tierra Blanca city has a higher CKD rate compared to other Mexican cities, but its principal cause has not been found yet. Main factors related to CKD are carbonated beverage consumption, diabetes, obesity, hypertension, heat stress, dehydration, and intoxication by pesticides, heavy metals, and/or hydrocarbons. The aim of this work was to evaluate hydrocarbon pollution in Tierra Blanca domestic fresh-water related to CKD and to integrate this information with other main factors in order to suggest precautionary actions taking account of key actors. We found hydrocarbons in the water wells of the city and the presence of other risk factors, which creates a perfect storm for CKD. Additionally, key actors were identified in order to follow precautionary principles related to CKD cases in Tierra Blanca.

1. Introduction

Chronic kidney disease (CKD) is a common term for heterogeneous conditions that affect the function and structure of the kidney (Levey and Coresh, 2012). The CKD definition is centred on the presence of kidney damage or decreased kidney function (i.e. glomerular filtration rate [GFR] < 60 mL/min per 1·73 m^2) for > 3 months (Stevens and Levey, 2009). Kidney failure (GFR of < 15 mL/min per 1·73 m^2) is conventionally considered as the most severe consequence of CKD and symptoms are usually produced by complications of reduced kidney function. When symptoms are severe it can be treated only by dialysis and transplantation; kidney failure treated in this way is known as end-stage renal disease. Other consequences include problems of reduced GFR, such as increased risk of cardiovascular disease, cognitive impairment, acute kidney injury, infection and impaired physical function (Hsu et al., 2008). CKD is a global health problem for many populations in developing (Webster et al., 2017) and non-developing countries (Méndez-Durán et al., 2010, Shams et al., 2018, Ploth et al., 2018). The topic of the determinants of the health of populations is of great interest in the health programs of developed countries and international organizations. There is a consensus: the health of the populations is a set of complex factors that, by acting in a combined way, determines the levels of health of the individuals and the communities. It refers to the complex interactions between individual characteristics, social and economic factors, and physical environments. It is raised by numerous authors and experts in the field that physical factors in the natural environment (for example, water quality) are key influences on health (Romero-Placeres et al., 2007). In the case of some non-developed countries, as México, kidney disease is not considered in the most popular health programs i.e. *seguro popular* (Tamayo y Orozco and Lastiri-Quirós, 2016). End-stage renal failure in Mexico is a catastrophic disease and there is no electronic database to accurately determine the characteristics of patients in dialysis programs (Méndez-Durán et al., 2010).

In developed countries, CKD is usually related with diabetes, old age, high blood pressure (hypertension), obesity, and cardiovascular disease, with diabetic glomerulosclerosis and hypertensive nephrosclerosis as the supposed pathological entities; however, exact diagnosis is frequently difficult (Levey and Coresh, 2012). Additionally, in non-developed countries currently dehydration and chronic heat stress is considered a key contributory etiologic factor (Soderland et al., 2010; Jayasumana et al., 2017; Valcke et al., 2017). However, environmental pollution factors such as pesticides, heavy metals, and hydrocarbons, ought to be considered as well due to scarce control. Epidemics of chronic kidney disease of unknown (CKDu) etiology take place in Sri Lanka, India, Central America, and beyond. Although also being observed in women, CKDu is concentrated among men in agroindustrial sectors. While some studies report evidence which points towards pesticides used in agricultural activities (For example, sugarcane

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culture) as the cause of CKDu in agricultural workers (Jayasumana et al., 2017), other studies (Valcke et al., 2017) provide limited evidence for an association between regional CKDu epidemics and pesticides but, a role of nephrotoxic agrochemicals cannot be conclusively discarded given the poor pesticide exposure assessment in the majority of studies. Aliphatic and aromatic hydrocarbons are strongly related to kidney disease (EPA, 2009), however, information about hydrocarbon exposure, aliphatic and aromatic, related to kidney disease is practically non-existent in undeveloped agricultural regions. Finally, some heavy metals like cadmium, mercury, lead, chromium, and platinum are also related to the increase of CKDu risk (Barbier et al., 2005; Johri et al., 2010; Jha et al., 2013).

In Mexico, the National Institute of Statistics and Geography (INEGI, 2016) and Veracruz (province of Mexico) State Agency of Health (SSV, 2016) reports an epidemic of CKDu in the agroindustrial region of Tierra Blanca, Veracruz. However, information about CKDu risk factors in Tierra Blanca is practically non-existent and no actions, taking into account the Precautionary Principle (UNESCO, 2005), are carried out by key actors (Noreña-Aristizaba, 2017) as an influential and very important part in decision making.

The aim of this work was to evaluate hydrocarbon pollution in domestic fresh-water in Tierra Blanca related to CKD and to integrate this information with other main factors in order to suggest precautionary actions taking account of key actors. Part of our objective was to start to generate information and explore the possible risk factors in Tierra Blanca.

2. Materials and methods

2.1. Sampling points

Tierra Blanca city was chosen as a study area in Veracruz, Mexico due to higher CKD cases compared (number of patients with CKD) to other cities in Veracruz (INEGI, 2018). Tierra Blanca location is showed in Fig. 1a. A total of 28 samples were taken from 10 sample points which corresponds to the fresh-water wells of the city as shown in Fig. 1b and Table 1. The sample was taken from a pressurized source, labelled and kept at low temperatures during transport to the laboratory (6 ± 2 °C). The entire procedure was following the Mexican normative (NOM-250-SSA1-2014, 2014).

2.2. Hydrocarbon concentration evaluation

Hydrocarbons were extracted using hexane (1:1) as solvent (Lizardi-Jiménez et al., 2013). Gas chromatography (TRACE 1310, Thermo Scientific, USA) was used to analyse the presence of hydrocarbons in samples, at 340 °C with a flame ionization detector, a TR-5 column (30 cm × 0.32 mm), an autosampler (TriPlus SH, Thermo Scientific, USA) and helium as the carrier gas. The injector and detector temperatures were constant at 200 and 340 °C, respectively. The temperature program was: 45 °C for 1 min; increasing by 5 °C min^{-1} until 110 °C; then by 15 °C min^{-1} until 330 °C. Hydrocarbon standard references for aliphatic and naphthalene (ASTM D2887-12, RESTEK; NJDEP EPH 10/08, RESTEK) were used. The detection limit for the hydrocarbon method was 0.002 mg L^{-1}.

Table 1
Fresh-water wells sampled in Tierra Blanca, Veracruz.

Sample point	Coordinates
1	18°27′1.49″N, 96°21′42.65″W
2	18°26′44.83″N, 96°21′3.68″W
3	18°26′44.83″N, 96°21′53.36″W
4	18°26′30.35″N, 96°21′8.78″W
5	18°26′10.90″N, 96°21′9.27″W
6	18°26′27.31″N, 96°21′33.91″W
7	18°26′45.70″N, 96°22′38.59″W
8	18°26′41.51″N, 96°21′51.38″W
9	18°27′16.08″N, 96°21′5.61″W
10	18°26′18.48″N, 96°20′28.02″W

2.3. Statistical analysis

A statistical analysis was performed to the total hydrocarbon concentration data by water well. In brief, a one-way analysis of variance (ANOVA) was used with the level of statistical significance set at $\alpha = 0.05$ and a Tukey-Kramer test using Jamovi free and open software (version 0.9.1.10).

2.4. Precautionary principle

According to the UNESCO (2005), a Precautionary Principle (PP) has to be used when considerable scientific uncertainties about probability, causality, magnitude, and nature of harm of a certain disease exist. PP consists on interventions that ought to be proportional to a certain level of protection according to the magnitude of possible harm, which means that cost effective measures can be applied or just environmental damage prevention speaking. Additionally, PP needs interventions before possible harm occurs, or before certainty about such

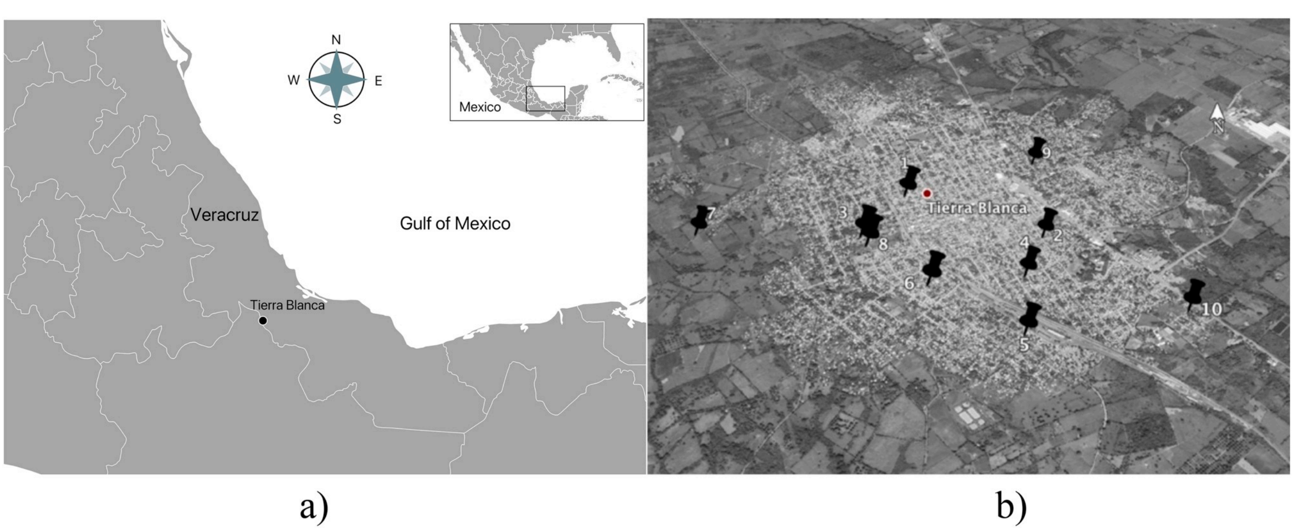

Fig. 1. Tierra Blanca, Veracruz, as the area of study and 10 fresh-water wells in the city.

harm can be achieved. However, in order to apply the PP a scientific analysis is mandatory. Therefore, there is a need for ongoing systematic empirical research for better understanding and more evidence (learning and long-term monitoring) with the aim to realize any potential situation beyond PP and for moving towards more traditional risk management.

2.5. Key actors

The intervention of key actors is important as a fundamental part of the PP, because it depends on the direction or status of a project, in which case it facilitates the processes of liaison and the improvement of policies and institutional processes (Noreña-Aristizaba, 2017). Almada-Navarro (2009) describe that the analysis of actors aims to identify that the actors can have a certain influence or that they are capable of modifying the meaning of the activities and the results of a project. According to Almada-Navarro (2009) the characteristics of the actors that should be taken into account for their intervention are:

- That they have knowledge of the proposal or Project;
- The interests related to the proposal or Project;
- Political positions in favour or against the Project;
- Their real or potential alliances with other actors, their possibilities to exercise power, or the leadership to affect the process.

Then it is understood that the key actors can be conceived as subjects that have a sense of belonging to the place where they live; being reflected in the knowledge of the place where they live, knowing the elements or causes that have made the conformation and structuring of their locality, and that have also intervened and that show interests for belonging to projects that bring collective benefits for the local society.

3. Results and discussion

3.1. CKD mortality in Tierra Blanca

Mortality related CKDu for inhabitants of Tierra Blanca is 57 per every 100,000 inhabitants. For Veracruz 15 and for the rest of the country less than one person per each 100,000 inhabitants (INEGI, 2016; SSV, 2016). Then, CKDu mortality occurs in Tierra Blanca 3.8 more times than in the rest of Veracruz and at least 57 times more than in the rest of Mexico. CKDu in Tierra Blanca is an epidemic challenge.

Tierra Blanca authorities have reported in local newspapers that the principal factor of CKD is the consumption of soft drinks (Al calor politico, 2018; Sin muros, 2018). Meanwhile Mexico is globally known as one of main consumers of this kind of carbonated beverages (Basu et al., 2013; Colchero et al., 2015), there is no evidence about higher levels of consumption in Tierra Blanca compared to the rest of the country. Furthermore, CKD cases associated with the consumption of carbonated beverages is usually associated in proportion to other chronical diseases such as diabetes, which is the main cause of CKD in developed countries (Pyram et al., 2012; McFarlane et al., 2013), hypertension, and obesity (Saldana et al., 2007; Jha et al., 2013; Alkhedaide et al., 2016). However, the relation between CKD death cases compared to death cases by diabetes, hypertension, and obesity in Tierra Blanca is as follows: per every diabetes, hypertension, and obesity death, there are 0.66, 36.54, and 97.44 deaths of CKD, respectively. Those death relations are at least 3, 7, and 1.25 times higher, respectively, than in other municipal zones in Veracruz (INEGI, 2018) indicating the existence of another cause of CKD risk for Tierra Blanca inhabitants than just soft drinks consumption. Carbonated soft drinks consumption can increase the risk of CKD but there is no evidence to support it as the unique cause of CKD in Tierra Blanca.

3.2. Heat stress and dehydration

Another risk factor to development CKD is heat stress and dehydration produced by high temperatures (Soderland et al., 2010; Valcke et al., 2017). According to the Mexican National Meteorological Service (SMN, 2018) the average annual Tierra Blanca temperature is 27.63 ± 0.39 °C with 42% humidity and a maximum reachable temperature (mrt) of 37.5 °C. Other municipal zones in Mexico with highest average temperature per year registered in Mexico are: La Candelaria, Campeche (31.04 ± 0.21 °C, 56% humidity and mrt of 40 °C), Pungarabato, Guerrero (30.35 ± 0.18 °C, 19% humidity and mrt of 40 °C) and Del Nayar, Nayarit (29.34 ± 0.30 °C, 36 humidity and mrt of 40 °C). However, Tierra Blanca has a higher ratio of KCD death cases per every 100 habitants than the other municipal zones, in brief 6.5, 7.79, and 11.75 higher than La Candelaria, Pungarabato and Del Nayar, respectively (INEGI, 2018). Heat stress and dehydration factors can also increase risk of CKD, however there is no evidence either to support it as a unique cause of CKD in Tierra Blanca. In fact, a study in Sri Lanka and Central America has reported that heat stress and dehydration may be key contributor factor, however, it cannot cause CKD by itself (Jayasumana et al., 2017).

3.3. Pesticides exposure

Veracruz State, where Tierra Blanca City is located, is the major sugarcane producer of México (Moreno-Seceña et al., 2016). Tierra Blanca cannot be understood without its historical relationship with the cultivation of sugarcane and its processing. > 50% of agricultural production in Tierra Blanca is sugarcane (SEFIPLAN, 2016) and this industry employs inhabitants of this region as producers of cane, day laborers, cutters, and workers of 5 sugar mills (Gutierrez-Pérez, 2012). Fresh-water ecotoxicity impacts due to pesticide use in sugar cane production are well-known (Nordborg et al., 2014) and CKDu is well related to organoclorated and organophosphorous pesticides and cadmium residues (Jayasumana et al., 2015, Soderland et al., 2010).

The risk of CKDu generated by pesticides can be even higher due to the presence of heavy metals like cadmium and lead, among others, which leads to the appearance of synergistic effects increasing pesticide and heavy metal toxicity in living organisms (Singh et al., 2017). Heavy metals as a factor of risk was explored in 2006 by Mendoza-Patiño et al., 2006 by taking water samples of Rio Blanco, a river who crosses part of the Tierra Blanca municipal zone. They found no evidence of heavy metals in the water, however they conclude that the chosen sampling technique could have influenced in their results. No other public research about heavy metals has been done in the zone since then, not even in domestic fresh-water or in pesticides used in the region. Pesticides and heavy metals as a risk factor of CKDu in Tierra Blanca continues being and needs to be an alternative to explore, especially since similar agricultural lands in Sri Lanka and Central America, where sugarcane is cultivated, have well known CKD prevalence which primarily affects agricultural workers (Jayasumana et al., 2017). However, studies about pesticide presence in Tierra Blanca water have not been done yet.

3.4. Hydrocarbon presence in sampling points

All sample points correspond to water wells that distribute fresh-water to the city for domestic and drinking use. Tables 2 and 3 show the concentration of hydrocarbons found in the sampling points. Analysis shows the presence of aliphatic hydrocarbons from 9 to 40 carbons, such as nonane (until $5.30 \pm 0.47\,mg\,L^{-1}$) and octadecane (until $3.84 \pm 1.53\,mg\,L^{-1}$), which are hydrocarbons related to various metabolic impairments that leads to kidney and liver diseases such as CKD, when chronically exposition, inhalation or consume occurs (EPA, 2009; Hassen et al., 2018; Ukolov et al., 2017). Sampling point 1 has a presence of naphthalene ($7.08 \pm 4.21\,mg\,L^{-1}$), a polycyclic aromatic hydrocarbon

Table 2
Hydrocarbons found in sampling points 1–5.

Hydrocarbon ($mg\,L^{-1}$)	Sampling point				
	1 (A)	2 (B)	3 (C)	4 (C)	5 (C)
Nonane	3.52 ± 0.37	3.37 ± 0.20	4.29 ± 0.21	4.01 ± 0.12	4.64 ± 0.24
Decane	ND	ND	0.88 ± 0.04	0.88 ± 0.02	0.95 ± 0.02
Napthalene	7.08 ± 4.21	ND	ND	ND	ND
Tetradecane	25.59 ± 3.62	ND	ND	ND	ND
Hexadecane	7.03 ± 1.58	ND	0.37 ± 0.18	1.04 ± 0.04	0.99 ± 0.01
Octadecane	3.84 ± 1.53	ND	0.31 ± 0.06	0.09 ± 0.00	0.11 ± 0.01
Eicosane	3.92 ± 1.67	0.85 ± 0.37	0.43 ± 0.00	0.49 ± 0.08	0.39 ± 0.01
Heneicosane	ND	0.19 ± 0.04	0.10 ± 0.05	0.26 ± 0.09	ND
Tetracosane	5.59 ± 2.47	2.35 ± 1.64	ND	ND	ND
Hexacosane	2.41 ± 0.68	2.58 ± 2.03	0.42 ± 0.00	ND	ND
Octacosane	9.76 ± 4.16	3.53 ± 1.70	0.74 ± 0.10	ND	ND
Triacontane	ND	3.77 ± 1.48	0.94 ± 0.02	0.82 ± 0.00	0.84 ± 0.01
Dotriacontane	337.94 ± 290.33	ND	1.27 ± 0.01	1.20 ± 0.02	1.16 ± 0.00
Hexatriacontane	2790.25 ± 710.54	136.80 ± 123.96	ND	ND	ND
Octatriacontane	14.25 ± 10.38	ND	ND	ND	ND
Tetracontane	2730.79 ± 155.02	ND	ND	ND	ND

Note: ± values show standard error for triplicate samples. *ND: Not detected. Letters in parenthesis are Tukey-Kramer test results (α = 0.05). Values with the same capital letter are not significantly different.

widely known to be carcinogenic (Lizardi-Jiménez and Aguirre-García, 2018), and hydrocarbons whose toxicity is scarcely reported but appears in high concentrations: hexatriacontane (2790 ± 710.54 $mg\,L^{-1}$) and tetracontane (2730.79 ± 155.02 $mg\,L^{-1}$). According to the Mexican normative, hydrocarbon concentrations in water are not allowed to exceed 10 μL^{-1} (NOM-250-SSA1-2014, 2014). Therefore, the hydrocarbon presence in fresh-water exceeds the maximum concentration allowed by the normative and is a risk to be considered in CKD prevalence among the Tierra Blanca population. The presence of hydrocarbons could be explained due to their migration from railway ties to the environment (Department of Agriculture, 2004; Moret et al., 2007). In fact, Tierra Blanca was founded and experienced its greatest growth boom as a city due to the railroad. Tierra Blanca became a strategic point for national and state railroad industry in its early years, especially as the railway workshop of the region was established in the heart of the city (Nambo, 2016), therefore hydrocarbon migration from railway ties to the Tierra Blanca environment acquires relevance as a hypothesis.

The main studied causes of CKD are present in Tierra Blanca and constitute "*a perfect storm*": one of the higher carbonated soft drink (in all of México) consumptions around world, severe heat stress (Valcke et al., 2017), pesticides (Jayasumana et al., 2015, Soderland et al., 2010), and hydrocarbon exposure. This combination of circumstances drastically aggravates the event and could explain the drastic CKD event in this region.

3.5. Precautionary principle proposal

The inhabitants of Tierra Blanca are extremely vulnerable to suffering CKD due to all factors of risk being present; patients with diabetes, hypertension, obesity, and dehydration, are all pathological entities that are fully met. Some presumed etiologic entities; pesticide exposure and water pollution by hydrocarbons are also present. This is a perfect storm. All factors that represent a risk are present, however there is no scientific evidence to determine the main cause of CKD in Tierra Blanca. PP ought to be applied when considerable scientific uncertainties about causality, magnitude, probability, and nature of harm exist, as in this case.

As the PP are limited to those concerns that are probable or scientifically tenable (that is, not easily negated) the actions proposed to inhabitants of Tierra Blanca are that the level of protection chosen must be based on the scientific evidence, that is, if the risk is evident and what is put into play is very high it can be considered a measure of total

Table 3
Hydrocarbons found in sampling points 6–10.

Hydrocarbon ($mg\,L^{-1}$)	Sampling point				
	6 (C)	7 (C)	8 (C)	9 (C)	10 (D)
Nonane	5.30 ± 0.47	3.86 ± 0.25	4.67 ± 0.34	4.30 ± 0.40	1.62
Decane	0.95 ± 0.00	0.84 ± 0.00	ND	0.91 ± 0.00	0.29
Napthalene	ND	ND	ND	ND	ND
Tetradecane	ND	ND	ND	ND	ND
Hexadecane	1.01 ± 0.00	0.92 ± 0.00	0.60 ± 0.30	0.91 ± 0.00	0.31
Octadecane	0.15 ± 0.01	0.04 ± 0.01	0.34 ± 0.00	0.07 ± 0.00	0.03
Eicosane	0.41 ± 0.00	0.38 ± 0.01	0.91 ± 0.62	0.37 ± 0.00	0.13
Heneicosane	ND	0.18 ± 0.00	ND	ND	0.06
Tetracosane	ND	ND	ND	ND	ND
Hexacosane	0.11 ± 0.01	ND	0.01 ± 0.00	0.02 ± 0.00	0.002
Octacosane	ND	ND	0.37 ± 0.00	0.40 ± 0.01	ND
Triacontane	0.90 ± 0.02	0.88 ± 0.02	0.84 ± 0.00	0.86 ± 0.00	0.30
Dotriacontane	1.17 ± 0.01	1.16 ± 0.00	0.77 ± 0.38	1.17 ± 0.00	ND
Hexatriacontane	ND	ND	ND	ND	ND
Octatriacontane	ND	ND	ND	ND	ND
Tetracontane	ND	ND	ND	ND	ND

Note: ± values show standard error for triplicate samples. *ND: Not detected. Letters in parenthesis are Tukey-Kramer test results (α = 0.05). Values with the same capital letter are not significantly different.

prohibition but if it does not exist, then the action proposals will be restrained as measures that constrain the possibility of the harm or that contain the harm, that means limiting the scope of the harm and increasing the controllability of the harm, in case it occurs.

Municipality authorities must design a public policy to inform the population of Tierra Blanca about the magnitude of the risk that exists between CKD and diabetes, hypertension, and obesity with respect to the state of Veracruz and in this way, health authorities of the municipality of Tierra Blanca must take into account civil participation in order to reduce the cases of diabetes, hypertension, and obesity in Tierra Blanca and to take additional precautions if they already have diabetes, hypertension, or obesity because there are other risk factors in Tierra Blanca that could elevate their potential to acquire CKD.

Aliphatic hydrocarbons of between 9 and 40 carbons were found in all the wells studied in Tierra Blanca and because aliphatic of between 4 and 18 carbons have effects on the kidney and liver (EPA, 2009; Hassen et al., 2018; Ukolov et al., 2017) it is unacceptable to not take actions to discard the risk. This is unacceptable because this risk threatens the lives of > 100,000 inhabitants in Tierra Blanca. The CKD is an irreversible and very expensive disease; dialysis and transplantation are necessary. The formulation is 'serious and irreversible damage'.

The intervention proposals must be proportional to the chosen level of protection and the magnitude of possible harm, for this reason the proposal is: 1. Inhabitants of Tierra Blanca ought to eliminate the direct consumption of water from Tierra Blanca wells and just drink purified water, free of aliphatic hydrocarbons and other contaminants; 2. Municipality authorities must design a public policy to inform the population of Tierra Blanca about the risk that exists between CKD and drinking water contaminated by aliphatic hydrocarbons that contain the wells of Tierra Blanca; 3. As access to clean water is a human right that must be protected by the Mexican state, the municipal authorities of Tierra Blanca together with the state and federal government must design a public policy that guarantees the right to clean water as soon as possible; 4. There is a need for continuing systematic empirical search for evidence and better understanding with the aim to identify some potential risk. CKD pathogenesis in the studied areas would provide only the measurement of hydrocarbons in the biological material obtained from patients (for exam: urine, serum) then mandatory studies are needed.

The other precautionary proposals should be taken from a participatory process that includes the affected people and the different governmental, paired, or private agencies that are involved. It is also important to implement research to quantify the magnitude of the other risk factors exposed in this work.

3.6. Key actors identified

Tierra Blanca inhabitants, municipal authorities of Tierra Blanca, State authorities of Veracruz State, Health agencies of Veracruz, and academics from Tierra Blanca Technological Superior Institute (ITSTB) and Universidad Veracruzana are the main identified actors.

As the first link towards citizen participation, it is important to create a planning committee for the municipality of Tierra Blanca and Veracruz state government. Through the Social Development Directorate, established within the organizational chart of the City and Veracruz State Council, whose obligation is to invite the inhabitants, and especially key actors, because they are people or groups that can significantly influence a positive or negative intervention and are very important for a situation to manifest itself in a certain way (Tapella, 2007); the committee must be composed of an executive and a technical body; the first will be designated for the administration of financial resources, personnel hiring and coordination. The second will be responsible for the analysis, structure, and validation, this body can be made up of academics from Technological Superior Institute of Tierra Blanca and Universidad Veracruzana.

It is also important to implement territorial ecology politics in order to implement a program to protect the Tierra Blanca environment from local agriculture side-effects, i.e. use of pesticides. Some key actors who must to take part of the interventions and regulations are the Ministry of Environment and Natural Resources (SEMARNAT) and the National Water Commission (CONAGUA).

4. Conclusions

In addition to the presence of hydrocarbons in fresh-water wells, the city of Tierra Blanca has all the risk factors for CKD present, that is: diabetes, hypertension, obesity, heat stress, dehydration, pesticides, hydrocarbons and probably heavy metals too; making a perfect CKD storm for Tierra Blanca inhabitants. In order to find a solution, the Municipal, State, and Federal governments must take into account the Precautionary Principle and propose actions to the inhabitants of Tierra Blanca. The actions proposed must be in relation to the level of emergency showed by the scientific evidence. This work proposes that a public policy must be designed to inform the population of Tierra Blanca about the risks that exist in drinking fresh-water from wells. Furthermore, the Municipal, State, and Federal authorities must design a public policy to clean the fresh-water as soon as possible. Finally, in order to obtain more scientific evidence, an ongoing systematic empirical research (long-term monitoring and learning) needs to be done, not only in order to search for hydrocarbon presence, but also for pesticides presence in rivers and water wells, due to Tierra Blanca similarity to other well know places with high prevalence of CKD that point towards sugarcane culture as primary cause of CKDu.

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References

Al calor politico, 2018. Persisten casos de insuficiencia renal en Tierra Blanca, advierte Alcande; hay niños enfermos. https://www.alcalorpolitico.com/informacion/persisten-casos-de-insuficiencia-renal-en-tierra-blanca-advierte-alcalde-hay-ninios-enfermos-259212.html#.WxAUTVOFNsM, Accessed date: 31 May 2018.

Alkhedaide, A., Soliman, M.M., Salah-Eldin, A.-E., Ismail, T.A., Alshehiri, Z.A., Attia, H.F., 2016. Chronic effects of soft drink consumption on the health state of Wistar rats: a biochemical, genetic and histopathological study. Mol. Med. Rep. 13 (6), 5109–5117. https://doi.org/10.3892/mmr.2016.5199.

Almada-Navarro, E.M., 2009. El análisis de actores. Metodología para el análisis contextual en bibliotecología y estudios de la información. In: Martínez-Arellano, F.F., Calva-González, J.J. (Eds.), XXVI Coloquio de Investigación Biobliotecológica y de la Información, 1–3 October 2008, UNAM: Centro Universitario de Investigaciones Bibliotecológicas, Mexico City, pp. 167–181.

Barbier, O., Jacquillet, G., Tauc, M., Cougnon, M., Poujeol, P., 2005. Effect of heavy metals on, and handling by, the kidney. Nephron Physiol. 99, 105–110. https://doi.org/10.1159/000083981.

Basu, S., McKee, M., Galea, G., Stuckler, D., 2013. Relationship of soft drink consumption to global overweight, obesity and diabetes: a cross-national analysis of 75 countries. Am. J. Public Health 103 (11), 2071–2077. https://doi.org/10.2105/AJPH.2012.300974.

Colchero, M.A., Salgado, J.C., Unar-Munguía, M., Hernández-Ávila, M., Rivera-Dommarco, J.A., 2015. Price elasticity of the demand for sugar sweetened beverages and soft drinks in Mexico. Econ. Hum. Biol. 19, 129–137. https://doi.org/10.1016/j.ehb.2015.08.007.

Department of Agriculture, 2004. Polycyclic Aromatic Hydrocarbon Migration From Creosote-treated Railway Ties Into Ballast and Adjacent Wetlands. (Madison, Wisconsin).

EPA, 2009. Provisional Peer-Reviewed Toxicity Values for Complex Mixtures of Aliphatic and Aromatic Hydrocarbons. (Cincinnati, Ohio).

Gutierrez-Pérez, M., 2012. Análisis de producción de caña de azúcar en la región Papaloapan del estado de Veracruz (Thesis (Bachelor)). Universidad Autónoma Agraria "Antonio Narro".

Hassen, M.F., Tilouche, N., Ali, H.B.S., Atrous, S.E., 2018. Acute rhabdomyolysis and acute kidney disease due to butane inhalation. Trends Anaesth. Crit. Care. 18, 10–11. https://doi.org/10.1016/j.tacc.2018.01.005.

Hsu, C.Y., Ordoñez, J.D., Chertow, G.M., Fan, D., McCulloch, C.E., Go, A.S., 2008. The risk of acute renal failure in patients with chronic kidney disease. Kidney Int. 74, 101–107. https://doi.org/10.1038/ki.2008.107.

INEGI, 2016. Consulta interactiva de datos: Principales causas de mortalidad por residencia habitual, grupos de edad y sexo del fallecido para los Estados Unidos Mexicanos y para el estado de Veracruz de Ignacio de la Llave. http://www.inegi.org.mx/est/contenidos/proyectos/registros/vitales/mortalidad/tabulados/PC.asp?t=14&c=11817, Accessed date: 3 June 2018.

INEGI, 2018. Consulta interactiva de datos: Mortalidad. http://www.inegi.org.mx/est/lista_cubos/consulta.aspx?p=adm&c=4, Accessed date: 28 May 2018.

Jayasumana, C., Paranagama, P., Agampodi, S., Wijewardane, C., Gunatilake, S., Siribaddana, S., 2015. Drinking well water and occupational exposure to herbicides is associated with chronic kidney disease, in Padavi-Sripura, Sri Lanka. Environ. Health 14 (1). https://doi.org/10.1186/1476-069X-14-6.

Jayasumana, C., Orantes, C., Herrera, R., Almaguer, M., Lopez, L., Carlos-Silva, L., Ordunez, P., Siribaddana, S., Gunatilake, S., De Broe, M.E., 2017. Chronic interstitial nephritis in agricultural communities: a worldwide epidemic with social, occupational and environmental determinants. Nephrol. Dial. Transplant. 32, 234–241. https://doi.org/10.1093/ndt/gfw346.

Jha, V., Garcia-Garcia, G., Iseki, K., Li, Z., Naicker, S., Plattner, B., Saran, R., Wang, A.Y.-M., Yang, C.-W., 2013. Chronic kidney disease: global dimension and perspectives. Lancet 382 (9888), 260–272. https://doi.org/10.1016/S0140-6736(13)60687-X.

Johri, N., Jacquillet, G., Unwin, R., 2010. Heavy metal poisoning: the effects of cadmium on the kidney. Biometals 23, 783–792. https://doi.org/10.1007/s10534-010-9328-y.

Levey, A.S., Coresh, J., 2012. Chronic kidney disease. Lancet 379 (9811), 165–180. https://doi.org/10.1016/S0140-6736(11)60178-5.

Lizardi-Jiménez, M.A., Aguirre-García, G.J., 2018. Carcinogenic hydrocarbon pollution in Quintana Roo's sinkholes: biotechnology for remediation and social participation for prevention. Int. J. Chem. React. Eng. 20170245. https://doi.org/10.1515/ijcre-2017-0245.

Lizardi-Jiménez, M.A., Leal-Bautista, R.M., Ordaz, A., Reyna-Velarde, R., 2013. Airlift bioreactors for hydrocarbon water pollution remediation in a tourism development pole. Desalin. Water Treat. 54 (1), 44–49. https://doi.org/10.1080/19443994.2013.876670.

McFarlane, P., Gilbert, R.E., Macallum, L., Senior, P., 2013. Chronic kidney disease in diabetes. Can. J. Diabetes 37, 129–136. https://doi.org/10.1016/j.jcjd.2013.01.037.

Méndez-Durán, A., Méndez-Bueno, J.F., Tapia-Yáñez, T., Montes, A.M., Aguilar-Sánchez, L., 2010. Epidemiología de la insuficiencia renal crónica en México. Dial. Trasplant. 31 (1), 7–11. https://doi.org/10.1016/S1886-2845(10)70004-7.

Mendoza-Patiño, N., de León-Rodríguez, J.A., Fernández-Saavedra, G., Figueroa, J.L., Páez de la Luz, H., Serrano-Soval, C., 2006. Tóxicos renales. Rev. Fac. Med. Uni. Nac. Auton. Mex. 49 (1).

Moreno-Seceña, J.C., Landeros-Sánchez, C., Vázquez, A.P., Palacios-Vélez, O.L., Chávez, M.D.R.C., Collado, C.J.L., 2016. Manejo y actitud del productor sobre la fertilización nitrogenada en caña de azúcar: un estudio de caso. RINDERESU 1 (1), 26–34.

Moret, S., Purcaro, G., Conte, L.S., 2007. Polycyclic aromatic hydrocarbon (PAH) content of soil and olives collected in areas contaminated with creosote released from old railway ties. Sci. Total Environ. 386 (1–3), 1–8. https://doi.org/10.1016/j.scitotenv.2007.07.008.

Nambo, J.B., 2016. Tierra Blanca: 1915–1946. Agys Alevin S.C., Mexico City.

NOM-250-SSA1-2014, 2014. Agua para uso y consumo humano. Límites máximos permisibles de la calidad del agua y requisitos sanitarios que deben cumplir los sistemas de abastecimiento de agua públicos y privados, su control y vigilancia. Procedimiento sanitario de muestreo. Ciudad de México: Norma Oficial Mexicana.

Nordborg, M., Cederberg, C., Berndes, G., 2014. Modeling potential freshwater ecotoxicity impacts due to pesticide use in biofuel feedstock production: the cases of maize, rapeseed, salix, soybean, sugar cane, and wheat. Environ. Sci. Technol. 48 (19), 11379–11388. https://doi.org/10.1021/es502497p.

Noreña-Aristizaba, O.P., 2017. ¿El principio de precaución hace parte del plan decenal de salud pública de Colombia 2012–2021? Luna Azul (45), 266–286. https://doi.org/10.17151/luaz.2017.45.14.

Ploth, D.W., Mbwambo, J.K., Fonner, V.A., Horowitz, B., Zager, P., Schrader, R., Fredrick, F., Laggis, C., Sweat, M.D., 2018. Prevalence of chronic kidney disease, diabetes and hypertension in rural Tanzania. Kidney Int. Rep. 3 (4), 905–915. https://doi.org/10.1016/j.ekir.2018.04.006.

Pyram, R., Kansara, A., Banerji, M.A., Loney-Hutchinson, L., 2012. Chronic kidney disease and diabetes. Maturitas 71, 94–103. https://doi.org/10.1016/j.maturitas.2011.11.009.

Romero-Placeres, M., Álvarez-Toste, M., Álvarez Pérez, A., 2007. Los factores ambientales como determinantes del estado de salud de la población. Rev. Cubana Hig. Epidemiol. 45 (2).

Saldana, T.M., Basso, O., Darden, R., Sandler, D.P., 2007. Carbonated beverages and chronic kidney disease. Epidemiology 18 (4), 501–506. https://doi.org/10.1097/EDE.0b013e3180646338.

SEFIPLAN, 2016. *Sistema de información municipal: Cuadernillos municipales de Tierra Blanca*. Veracruz: Sistema de Finanzas y planeación del estado de Veracruz.

Shams, S., Khan, H.A., Ayaz, M., Afridi, S.G., 2018. Efficacy of atorvastatin on proteinuria in chronic kidney disease patients of district Mardan, Pakistan. J. Appl. Environ. Biol. Sci. 8 (3), 81–87.

Sin muros, 2018. Existen 600 personas con insuficiencia renal en Tierra Blanca. http://www.sinmuros.com.mx/noticias/xalapa/15728/existen-600-personas-con-insuficiencia-renal-en-tierra-blanca.html, Accessed date: 31 May 2018.

Singh, N., Gupta, V.K., Kumar, A., Sharma, B., 2017. Synergistic effects of heavy metals and pesticides in living systems. Front. Chem. 5 (70), 1–9. https://doi.org/10.3389/fchem.2017.00070.

SMN, 2018. Resumenes mensuales de temperatura y lluvias. http://smn.cna.gob.mx/es/climatologia/temperaturas-y-lluvias/resumenes-mensuales-de-temperaturas-y-lluvias, Accessed date: 31 May 2018.

Soderland, P., Lovekar, S., Weiner, D.E., Brooks, D.R., Kaufman, J.S., 2010. Chronic kidney disease associated with environmental toxins and exposures. Adv. Chronic Kidney Dis. 17 (3), 254–264. https://doi.org/10.1053/j.ackd.2010.03.011.

SSV, 2016. Subdirección de Innovación e información de salud; Departamento de Bioestadistica. Principales causas de mortalidad en el estado de Veracruz. https://www.ssaver.gob.mx/planeacionydesarrollo/bioestadistica/, Accessed date: 3 June 2018.

Stevens, L.A., Levey, A.S., 2009. Current status and future perspectives for CKD testing. Am. J. Kidney Dis. 53 (3), S17–S26. https://doi.org/10.1053/j.ajkd.2008.07.047.

Tamayo y Orozco, J.A., Lastiri-Quirós, H.S., 2016. La enfermedad renal crónica en México. Hacia una política nacional para enfrentarla. Academia Nacional de Medicina de México, Mexico City.

Tapella, E., 2007. El mapeo de actores claves. http://ceppia.com.co/Herramientas/Herramientas/Que-es-el-mapeo-de-actores-Esteban-Tapella.pdf, Accessed date: 11 June 2018.

Ukolov, A.I., Kessenikh, E.D., Radilov, A.S., Goncharov, N.V., 2017. Toxicometabolomics: identification of markers of chronic exposure to low doses of aliphatic hydrocarbons. J. Evol. Biochem. Physiol. 53 (1), 25–36. https://doi.org/10.1134/S0022093017010033.

UNESCO, 2005. The precautionary principle. http://unesdoc.unesco.org/images/0013/001395/139578e.pdf, Accessed date: 3 June 2018.

Valcke, M., Levasseur, M.E., da Silva, A.S., Wesseling, C., 2017. Pesticide exposures and chronic kidney disease of unknown etiology: an epidemiologic review. Environ. Health 16 (1), 49. https://doi.org/10.1186/s12940-017-0254-0.

Webster, A.C., Nagler, E.V., Morton, R.L., Masson, P., 2017. Chronic kidney disease. Lancet 389 (10075), 1238–1252. https://doi.org/10.1016/S0140-6736(16)32064-5.

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