NITRATES POLLUTION AT THE "HURLINGHAM" DISTRICT WATERS. SPATIAL ANALYSIS WITH GEOGRAPHIC INFORMATION SYSTEMS.

Alves de Castro, María Victoria
Geography Graduate, F.C.H., UNCPBA.

INTRODUCTION

Underground water pollution is considered one of the most serious problems of Argentina and it directly affects wide and dense urban areas of the country, such as the Buenos Aires Metropolitan Area.

One of the most commonly verified pollutions in the waters found near the big urban centers is the Nitrates (NO_{3-}) contamination. Such pollution could be linked to the great concentration of urban zones that do not have sewage service and that live with a big number of cesspits. Although these represent precise zones, facing the urban density, they produce chemical pollution with nitrates by diffuse infiltration.

In the Hurlingham district, the main source of water to supply the people is the underground source and only 28% of the inhabitants have access to running water which, from the quality of life studies point of view, will be an improvement variable for the people quality of life. However, as the District is mostly urbanized and running water and sewages are not available, it is supposed that the people with running water, although they are not so vulnerable socially speaking, are vulnerable to the nitrates pollution risk as well as the rest of the population. From a water sampling and analysis done within the frame of this research, it could be proved that a part of the Hurlingham population supplied by the *"Cooperativa Parque Quirno"* [Parque Quirno Cooperative], receives water with higher nitrate levels allowed by the Argentinean Food Code [*Código Alimentario Argentino*]. This allows to verify the presence of this kind of pollution in the population that is supplied by private drillings (underground water) as well as among the people who have access to network water services.

This report tries to do a preliminary contribution to the urban quality of life and social vulnerability study by nitrates pollution in Hurlingham. Therefore, it has been considered to evaluate, first, the social characteristics or life conditions of the population and the areas and extensions of water and sewages services and equipments. Besides, it was also considered to set, through a Geographic Information System (GIS), a space analysis about the coexistence of zones with worse life conditions than places with less availability of water and sewages; gather information and data of water samples that have high nitrate levels; adjust the information inside the GIS and prove, through the spatial analysis, the Hurlingham district places which are the most vulnerable.

The underground water source in Hurlingham is little investigated. It is ignored, neglected and nobody controls how it is polluted and who does it. Hurlingham has been facing the high concentration of nitrates in the *"Puelches"* aquifer for several years. In this situation, it is necessary to know and evaluate the population social vulnerability and dangerousness that use this source as an essential resource to obtain water. It is also planned to evaluate the running water quality which is distributed in a small part of Hurlingham and that has access to this service. A suitable assessment will allow to get the necessary contributions to improve this District's population quality of life.

METHODOLOGY

This research starts with documents' collections and bibliographic analysis of several works from which the theoretical frame is defined and analyzed with the main definitions and methodologies of

the present situation. From this first part, the main concepts and definitions selection arise: social vulnerability and risk, urban quality of life, urban basic services (network water and sewages equipment), urban quality of life perception, aquifer mean and natural dynamic. Likewise, analogical base cartography and up-date material of the study area were looked for.

To calculate the vulnerable population before nitrates pollution in water, a series of geographical information layers (census areas and fragments, urban blocks, sample points localizations, etc.) were produced. These layers formed part of data tables that allowed to make thematic maps and their analysis within a vector Geographical Information System (GIS).

To build and organize the GIS, the topographic chart and the satellite image chart of "Campo de Mayo" (scale 1:50.000, sheet 3560-12-4) that belong to the Military Geographic Institute (IGM for its name in Spanish) were used as reference. Within the GIS, work was done with several areas information layers (District limits, urban blocks, neighborhoods, public services covered areas, census areas and fragments, etc.), points (water samples localization, public taps, water extraction pumps, etc.) and lines (streets' axis, neighborhoods limits, railways, streams, etc.). The information layers have been stipulated taking into account the analysis needs, authorizing some and disaffirming others from the GIS own commands. By requiring cadastral, neighborhood division and sewages and running water coverage maps to the Hurlingham District Municipality, the main updating about these topics were entered into the GIS.

To analyze and evaluate the population social vulnerability, certain indicators were selected and a Quality of Life index was made, based on the available data per area and fragment according to the last INDEC (2001) Population, Dwellings and Homes Census. Likewise, an updated (2008) semi-stratified survey specially designed for the research was performed. This survey was applied to some District places taking into account the number of inhabitants and the sewages and network service availability in each of them.

The water sampling points' selection was done keeping in mind the census areas and fragments division, the inhabitants' density, the water pollution previous data provided by the Bromatology Direction of the Hurlingham Municipality and the water obtaining origin (private drillings or network water).

Finally, considering the social vulnerability and the nitrate pollution risk, thematic maps were made to spatially correlate the Hurlingham quality of life index with the nitrate pollution levels obtained from a sampling.

DEVELOPMENT

Theoretical Framework:

Risk, threats and vulnerability appear as essential concepts for the nitrate pollution analysis and its incidence in the Hurlingham population quality of life.
The ***risk*** concept is presented as *"the probability that something harmful or damaging happens to a population (people, physical structures, productive systems, etc.), or to a segment of it"* (Lavell, Allan. 1996, Page 32). Likewise, the ***risk*** supposes the existence of two main factors: threats and vulnerability. *"The threat is the probability of a harmful physic event for society; vulnerability is the society or society element tendency to suffer damage"* (Lavell, Allan. 1999, Page 3). Although these factors are considered independently, it is impossible to speak about threats without the presence of vulnerability and vice versa.

Vulnerability influences on the lack of economic, political and technical means to face the phenomena that affect the population. In this way, vulnerability is socially defined and, therefore, it is a changeable category.

In this work, the risk is analyzed from a double perspective: natural and social. This perspective is defined by the interaction between the dangerousness or threat and the social vulnerability.

Dangerousness is determined by the aquifer vulnerability to the nitrate pollution; the social vulnerability squares with the population life conditions and its answer capacity facing the dangerousness or threat that bring the ingestion of water with high nitrate levels.

The access to drinking water affects the population quality of life. This concept tries to reflect the satisfaction of individuals and different social groups as well as the society welfare. Drinking water is a basic need for population and its supply is an essential service to keep and improve a population quality of life. In the Hurlingham district, there is a population that does not have access to drinking water and does not have urban public services, such as running water and sewages. This situation gets worse with the underground water pollution, place from which most people obtain the water they daily consume. In this way, the non-drinking water use carries short, medium and long term risks related to human health and it places people facing a serious situation of social vulnerability.

Area of Study:

The analyzed study in this work is focused on Hurlingham, district of the Buenos Aires Metropolitan Area. It is geographically located in the central zone of Buenos Aires Province (GBA for its name in Spanish), in the north-east of this province and 17Km from Buenos Aires Capital City. It has a total surface of 35.43 Km^2.

This area of study geomorphology squares with the Ondulated Pampa, sub-region of the Pampean Plain. The base in which it is placed is a landslide of the Brasilia Massif. The hillocks and uneven surfaces caused by fluvial erosion are features of the Ondulated Pampa. It has an altitude that ranges between 15 and 30msnm (for its name in Spanish, meters above sea level).

The underground on which the area of study is placed has three interrelated hydrogeological sections called *Epipuelches*, *Puelches* and *Hipopuelches*. In each of these sections there are impermeable sediments (aquicludes), medium-permeable complexes (aquitardes) and permeable sedimentary packages (aquifers); the underground waters used by Buenos Aires Province population, Hurlingham in particular, comes from these aquifers.

The most important aquifer is *Puelches*, which is 230,000 Km^2 long and is situated under the Ondulated Pampa. It approximately stores 300 billons liters of water. This aquifer waters supply the domestic and industrial use.

In this area, the weather is warm and wet, characterized by mild winters and hot summers. The annual rains average is 1,239mm and they feed the zone's fluvial courses (Reconquista River and Soto and Morón Streams).

The current territories of the Hurlingham, Ituzaingó and Morón municipalities constituted, until 1995, an only district: the old Morón District. It was created around 1784, when the administration of a growing rural zone ordered territory divisions.

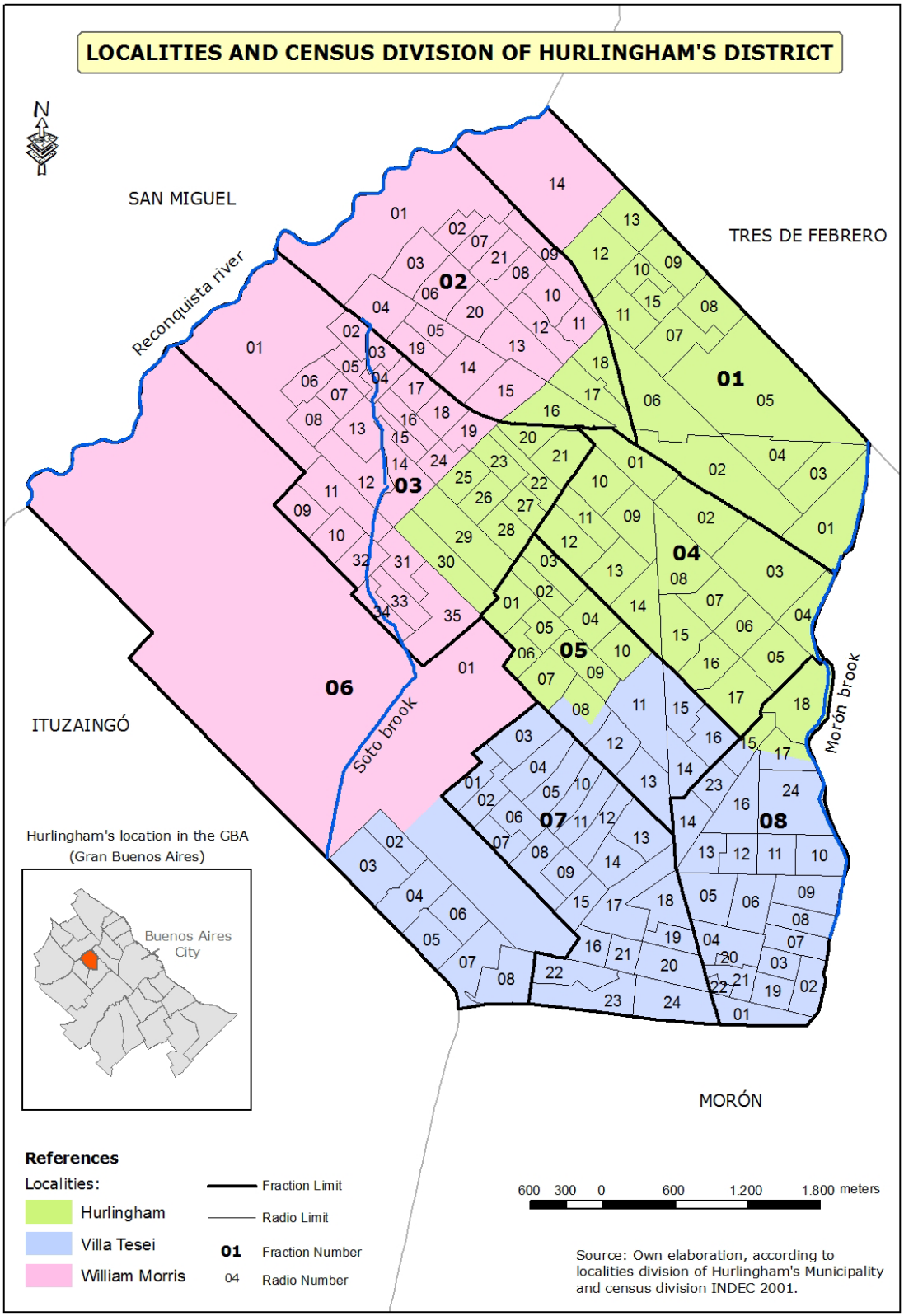
Hurlingham origins start in 1857, although there are opposite views on its foundation date. From that moment, the population started growing until the Villa Santos Tesei industrial zone and, for a long time, William C. Morris rural zone were introduced.

The current District limits were established by Act 11610 of the Buenos Aires Province Legislative Body on 28th December 1994. From that moment, the District is divided into three areas: Hurlingham, Villa Tesei and William C. Morris.

According INDEC, Hurlingham had a total of 172,245 inhabitants in 2001. From that number, 60,165 inhabitants belong to Hurlingham district, 63,164 inhabitants belong to Villa Tesei and 48,916 inhabitants belong to Williams C. Morris. Taking into account the Hurlingham Municipality publications, the District currently has 204,971 inhabitants and a density of 5,785 inhabitants per

km².

As regards the soil use, Hurlingham has an urban structure, without rural zonification, divided into residential and industrial use. It is characterized for its wide zonificated sector, as semi-industrial, in the center and north of the District, its industrial zone consolidated in the edges of Morón Stream and on the Vergara Avenue and the big mixed residential zones that produce a non-wished mixture in the territorial ordering of the District.



Nitrates water pollution in Hurlingham

According to the World Health Organization (WHO) "water must be considered polluted when its composition or state is altered in such a way that it does not have the proper conditions for the group of uses for which it would be assigned in its natural state" (Foguelman, D.; Brailovsky, A. 1999, Page 63). The water alteration is related to the changes or modifications in its physical, chemical and biological properties that produce the loss of potability for human use.

Nowadays, nitrates pollution appears as the most spread at local, regional and world scale. "It has become one of the main deterioration causes of underground water in developed countries and in developing ones" (Auge 2004 Page 16). This kind of pollution is widely linked to most part of human activities and it appears in urban areas supplied with sanitary services and those which do not have them.

Nitrates (NO3) are salt anions derived from nitrogen which are easily swept into the ground and to the aquifers through drainage water. They are naturally found in water and soil but in small quantities. They also are in most fertilizers and in the liquid wastes released by cesspits.

The organic matter is degraded by the biological activity generating amines that produce organic nitrogen which becomes Nitrite (N02) and Ammonia (NH4). These are unstable and rapidly oxidized to form Nitrates (N03), which are the most stable and mobile forms of the nitrogenous matter (Auge 2004 Page 17).

In urban areas that do not have sewage services, such as most of Hurlingham, the NO3 derive from the organic matter degradation, mainly from fecal origin. The main source of emission is the cesspit, from which the fecal wastes are infiltrated. In cities that have sewage services, the nitrates come, among other causes, from the leakages that are produced in the net.

National and international organisms determine the nitrate maximum levels allowed in water for human use. In 2004, the World Health Organization (WHO) published a new revision of the drinking water quality standards whose aim was avoid epidemic outbreaks and diseases related to water. At that time, the maximum value of nitrate in water was fixed in 50 mg/l. On the other hand, the United States Environmental Protection Agency (EPA) establishes as maximum limit 10 mg/l of nitrate in water. In the European Union, the maximum value of nitrates in drinking water allowed was established in 50mg/l, during the first months of 2003 through regulation 98/83/EU. In Argentina hygienic, sanitary and bromatologic dispositions are regulated by Act 18.284, known as Argentinean Food Code (CAA for its name in Spanish). In article 982 of the mentioned Code, the limit of nitrates is fixed in 45 mg/l.

Nitrates are pollutant substances highly mobile and stable, mainly in aquifers that have a good quantity of oxygen. These pollutants produce certain adverse effects on health, producing among others, methaemoglobinaemia in children. The nitrates that are consumed through water become nitrites inside the stomach; the haemoglobin becomes methaemoglobin preventing the normal transport of oxygen in blood. The symptoms of this illness are often confused with cardio-respiratory diseases or summer diarrheas. In a still on milk child, it causes deficiencies in his/her evolution and it can even cause death. As it is not a compulsory-report disease, there are not official statistics on this topic. Therefore, knowing this pollutant's characteristics and its injuries on human health is very important to counteract its adverse effects on human beings.

In Hurlingham district, the nitrates pollution becomes relevant when a group of people made formal claims in 2005. Such claims were published in a local newspaper (*El Espejo*. Year 15, Number 236, February 2006) where it was determined that, according to an ETOSS report, in July 2005, five of the seven wells from which the *"Cooperativa Parque Quirno"* took water, the nitrate was high and it was higher than 100 mg/l. This was mainly because the whole District does not have a sewage system. Therefore, the feces are thrown in deficient septic tanks that allow the leakage of this substance into the underground waters surrounding those places. This problem must be understood

by population. If it is not managed and solved, it will create a great uncertainty for the future.

The research work:

a) Making-up of the quality of life

As it is possible to determine different degrees of social vulnerability within a city, work was done analyzing and processing statistically census data discriminated by urban areas and fragments available for the 2001 Population, Dwellings and Homes Census (INDEC). The main goal was to integrate them into de GIS and build up the quality of life index (QLI) for Hurlingham District. In this way, the most vulnerable areas to the nitrates pollution were defined, according to the quality of life of the population. To build up this index, a total of nine variables were considered. These were the following:

1***) Education:***

a) Population percentage that never attended an educative building.
b) Population percentage with complete high school instruction level.
c) Population percentage with complete university instruction level.

2) ***Housing:***

a) Housing percentage – A type of house.
b) Housing percentage – Shanty and hut types of houses.
c) Housing percentage with no sewages.
d) Housing percentage with no running water net.

3) Houses:

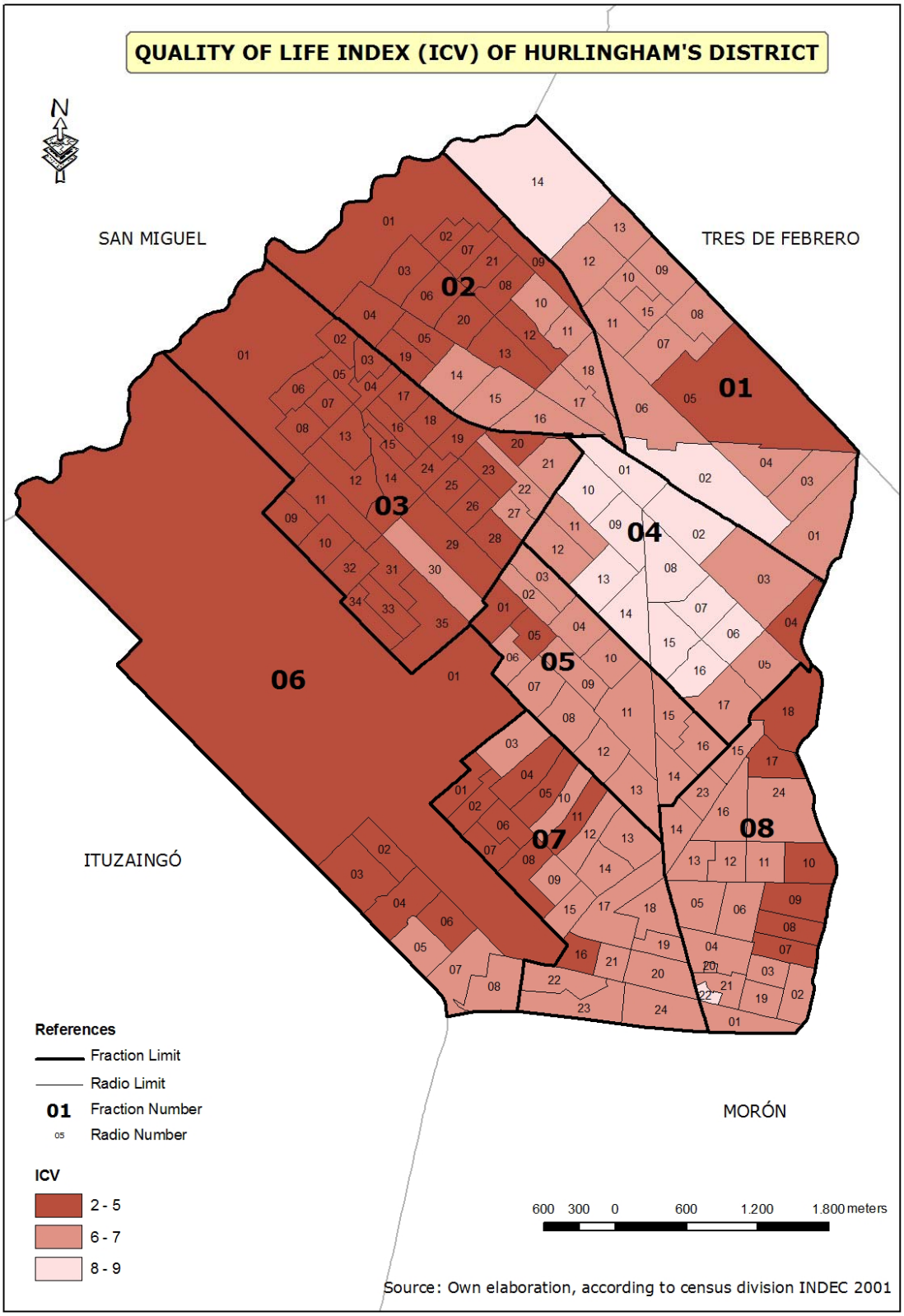
a) Houses percentage with extreme overcrowding (more than three people per four).

4***) Health:***

a) Population percentage with no health coverage.

The developing of this index was done through the use of a worksheet where the census areas and fragments were put in order in the first column, according to the spatial data integrated into the GIS. In the following columns, the before mentioned variables (quoted in percentage values) and the proper standardized values were introduced. Per each variable, valuation indexes were built up in ten intervals. According to each variable value, quality of life indexes values between 1 and 10 were allocated, being 10 the best situation and 1 the worst.

Afterwards, the quality of life final index, which was the result of each selected variable averages was calculated for each census area and fragment. Such worksheet becomes a Data base file (dbf) and was incorporated to the GIS built for Hurlingham district. This makes the thematic maps creation for each variable and for the final ICV (for its name in Spanish, Quality of life index).


QUALITY OF LIFE INDEX (ICV) OF HURLINGHAM'S DISTRICT
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Source: Own elaboration, according to census division INDEC 2001

From the quality of life final map (ICV), the following results are shown:

- The best quality of life is found within fragments 01 and 04 of the District. This is determined by the prevailing kind of buildings, the education level (with a higher percentage of the population with complete university studies) and the services supply, such as network water (fragment 04).
- There is a clear difference between the central and the outlying zones on the District.
- The worst indexes are focused on the outlying zone, near Reconquista River and Morón Stream.
- The existence of a higher social vulnerability in sectors with quality of life lower levels is supposed according to the results.

b) Urban basic services

The sewage and running water coverage is included within the determination of social vulnerability, because public services are considered essential and determinant parts in the life conditions of a population. That is why; the sewage and water coverage map was correlated spatially with the Hurlingham ICV map.

The water coverage map was built taking into account the information given by the Hurlingham Municipality and it allows the spatial correlations among areas with network water coverage, the blocks map and occupied houses, which allows the determination of the population percentage that has this service.

Likewise, the covered areas determination allowed the establishment of the waters stratified sampling to obtain samples that make the nitrates concentration analysis possible. As this kind of sampling must include every social stratum, it was calculated that, at least, one water sample must be obtained from the different outlying areas that do not have access to running water. The lack of sewages coverage in almost the whole District was also taken into account to determine the sampling.

The coverage map of network water allows to prove that in Hurlingham there are two ways of obtaining water: network water and water per private mechanic pumping (underground water). Only 28% of the whole Hurlingham population has network water service. The rest is supplied by underground water, with manual pumping or electric pumps. A very small percentage of houses take water from wells.

The biggest network water renderers of services in Hurlingham are *Agua y Saneamientos Argentinos* (AySA- Argentinean Sanitary and water), in Villa Tesei, and *Cooperativa de Parque Quirno*, in a sector of Hurlingham district.

Cooperativa Parque Quirno distributes water to about 4,800 people and it has received claims for supplying water with high levels of nitrate since 2005. Currently, the Cooperative is notified by Justice to normalize this situation; up to this date, the problem has not been solved.

Until 2007, Hurlingham was completely deprived from sewage coverage. Although nowadays there are no inhabitants connected to the sewage system, the Municipality is developing isolated works in different neighborhoods of the District, so population has the future possibility to be connected to the sewage network. The works are still very few and do not include the whole population.

c) Water samples

The field work included a total of 36 samples and it was done in two working days. Each sample was georeferenced with GPS to be included within the Hurlingham district GIS.

Once taken, the samples were transferred, within 24 hours, to the *Instituto de Formación Técnica y Superior* (IFTS – Higher and Technical Institute) N° 26 laboratory, situated in Buenos Aires Capital City. There, the nitrates analysis of each sample was done.

From the total of the samples taken, 24 were obtained from drillings with mechanic pumps (underground water) and 12 from network water connections. From the 24 samples whose origin is the underground water, 3 belong to community taps situated in the outskirts of the District, 1 belong to a school, 1 to a leisure activities centre, 1 to a community welfare centre, 1 belongs to a shop and 17 to private homes. From the 12 samples taken from network water connections, 3 belong to AySA control sampling points and 9 to samples taken in houses that receive the water supplied by the *Cooperativa Parque Quirno*.

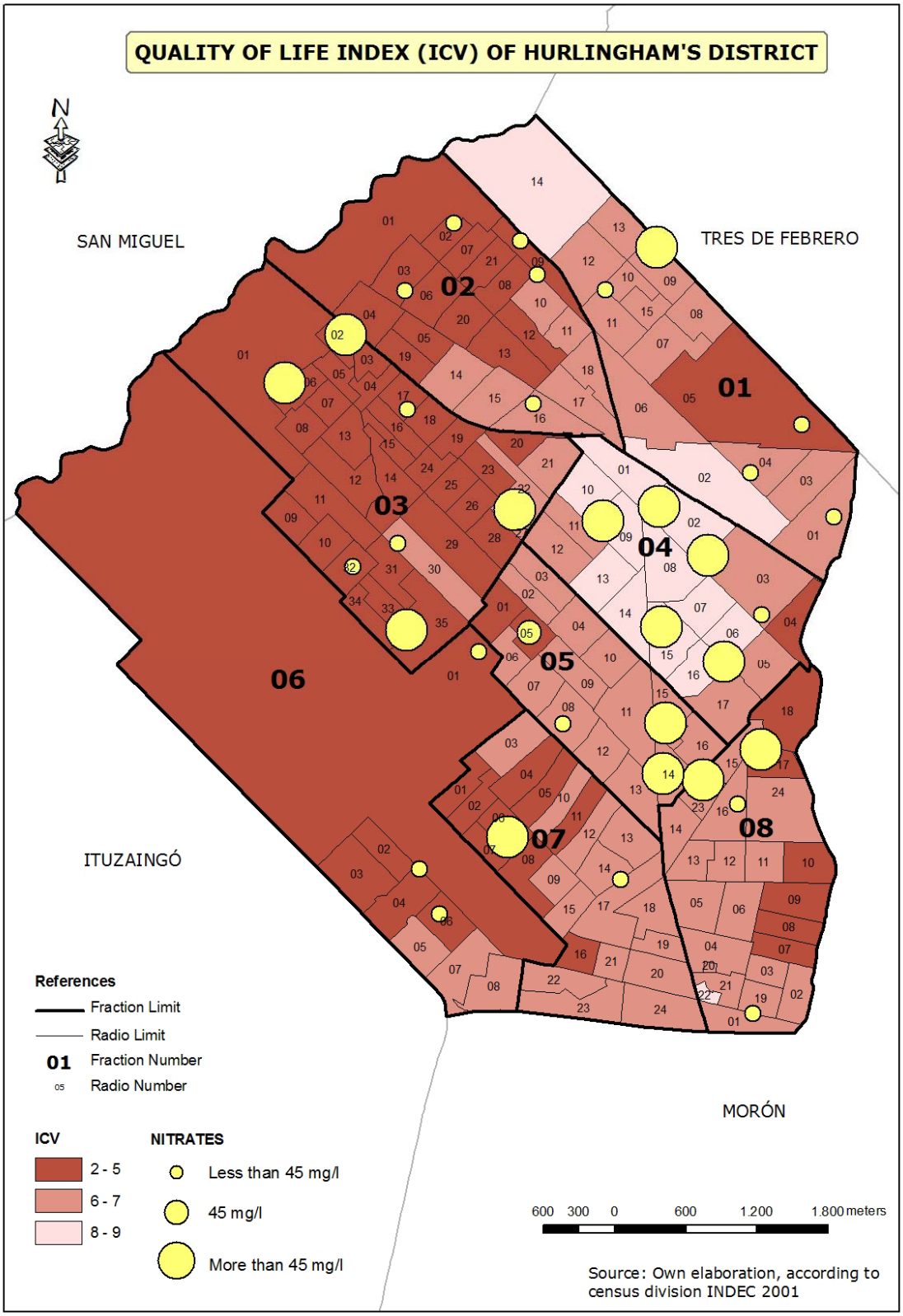
In each place where a sample was taken, a survey was done to obtain more information about inhabitants, house characteristics, characteristics of the way the water was obtained in the house, the place where the house's pipes end, the health coverage of the inhabitants and the perception that the population has regarding the environmental problems in Hurlingham district.

For the samples analysis, a La Motte colorimeter was used. Zinc was used to reduce the nitrates to nitrite. The nitrate originally present in the water reacts with the Chromotropic acid forming a red color in proportion to the nitrite quantity in the sample. The darker the color is, the higher is the nitrates concentration in the sample.

From the 36 samples taken, 41.6% (15 samples) are higher than the Nitrates values established by the Food Code. From the 12 samples taken within the zone supplied with network water, 8 (66.66%) have Nitrates values higher than the ones established by the Code; all of them belong to the zone supplied by the *Cooperativa Parque Quirno*. The maximum value was obtained in sample N° 17 with 98 mg/l. The paradox of this situation is that the higher quantity of nitrates is found within the area supplied with network water, being the population with best quality of life (according to the ICV map), the most vulnerable to nitrates pollution.

From the three samples belonging to the AySA coverage area, none of them showed values higher than the limits established by the Food Code. This situation is favored because the water AySA distributes in Hurlingham is obtained from *Río de la Plata* and it arrives through an underground canalization. This does not happen in the south of Buenos Aires Province, where AySA supplies the population with underground water and where it has had several problems regarding the nitrates levels in the water.

Taking into account the ICV built for the Hurlingham district, the biggest risk and social vulnerability to the nitrates pollution of the water agree with samples situated in network water coverage areas (fragment 4) and with higher values according to the quality of life index. This modifies the running water concept as an improvement for the population quality of life.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Source: Own elaboration, according to census division INDEC 2001

CONCLUSIONS

The recent development of this research allows the following conclusions:

- Due to the results obtained from the stratified sampling, it can be affirmed that there is Nitrates pollution in the water the Hurlingham population consumes, and that it would affect the 67% of the population that has running water, the 29.16% of the population that takes water from wells to be drunk and the 30% of the population that consumes water from community taps. Therefore, there is an important number of the population that is consuming water of a quality that puts human health in danger.
- According to the values of the population Quality of Life Index and their spatial correlation with the most dangerous zones for presence or risk to consume water with Nitrates higher than the values established by the Food Code, the greatest vulnerability to pollution is spatially correlated with the lowest life conditions and the zones with the highest quality of life and availability of network water service.
- The equipment of water services from different sources (water per battery of underground water extraction wells and per water supply taken by pipes from the river) does not guarantee the same supply of drinking water for the two places with network water.
- According to the data obtained, the values of the samples coming from underground water (that come from the battery of wells that the *Cooperativa Parque Quirno* manages) represent a higher danger than the ones found among the samples obtained from home extraction wells.
- Users trust the equipment of network water services, because they do not require consumed water analysis. <u>However, it does not guarantee drinking water.</u> Perhaps, the *lack of danger perception is based on what is called the environmental problems invisibility* before water pollutants (that are not seen) and it aims at considering the running water access as equivalent of drinking water; this is an indicator of quality of life.
- The equipment of water and sewage services has not gone together with the houses growing and it has always been smaller than the extension of the urban stain.
- Hurlingham presents a risk and vulnerability situation regarding the lack of water and sewage services coverage. There is a wide disparity according to its distribution and accessibility (only one sector of Villa Tesei has access to the running water distributed by AySA). The sectors to be promptly connected to the sewage network are very selective.
- Only the neighborhoods that have a better quality of life and higher incomes can face the lack of public services turning to the private services (expensive wells drillings and purchase of bottled water).
- The municipal authorities should control and guarantee the consuming of drinking water to the whole population and should be responsible or take into account the irregular situations of the private services which are not linked, such as the *Cooperativa de Parque Quirno*.
- Hurlingham welfare centers do not record statistics on water diseases and, much less, on methaemoglobinaemia in still on milk children and pregnant women, because it is not treated as an illness itself. This makes this situation more serious and covers even more this environmental problem.
- The Municipality should assume its public role explaining in mass campaigns that Nitrate is not eliminated, that it is concentrated when boiling water before being consumed.
- Facing the lack of awareness of the problem, the Municipality should take the initiative to make the proper control sampling of water pollutants and show the results to the community; otherwise it can never be in charge of a problem if its existence is not recognized.