HEALTH HAZARD IDENTIFICATION IN AN AGRICULTURAL-INDUSTRIAL AREA

Part I. Lifestyle factors and occupation

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ABSTRACT

Background. The change in the use of agricultural fields to industrial activities has created areas where both kinds of activities coexist competing for the water sources. Analyses revealed the presence of chlorine and chemical demand of oxygen in high concentrations, as well as volatile organic compounds such as chloroform, methylene chloride and toluene in the rivers Atoyac and Xochiac; these compounds are not considered in the environmental normativity of the country. Concern has arisen among the residents in this zone about the deterioration of the environment and the risk to their health and their children's.

Methods. A study was initiated to identify the hazards posed to the health of the population in this area. A questionnaire was designed to apply to a sample of the people living in 11 communities; this questionnaire included topics like general health, occupational history, familial antecedents of cancer and diabetes, as well as personal dietary habits, tobacco and alcohol use. Weight and height were recorded to estimate the body mass index.

Results. Three main areas of potential hazard could be determined: 1) occupational exposure to toxic chemicals and carcinogens in the petrochemical as well as in the denim laundry industries; 2) environmental exposure to organic volatile compounds present in the rivers Atoyac and Xochiac due to the industrial discharges, also present in the sewage system; 3) individual lifestyle factors also contribute to the hazards identified consisting on simultaneous smoking and drinking and a high body mass index in more than 50% of the adult population.

INTRODUCTION

The change in the use of agricultural fields to industrial activities has created areas where both kinds of activities coexist competing for the water sources. Such is the case in communities located close to rivers carrying industrial contamination.

These communities used to be producers of vegetables for human consumption that were sold in the markets of Tlaxcala, Puebla and México Cities and had a watering system typical of many other agricultural areas, consisting in channels, open to the air, built to distribute water around the parcels from the river Atoyac.

With the urbanization of the communities, underground sewer systems were built to drain on the same river, in the open air. In time, industries were established in the area, first a petrochemical plant and then, blue denim laundries and other textile industries, as well as other diverse and numerous enterprises that also used the watering channels as sewers, in the open air. The agricultural activities still are important for the economy of these communities, even though numerous accidents and the bad quality of the water are diminishing the productivity of the grounds.

This situation has been studied by an NGO, Centro Fray Julián Garcés, Human Rights and Community Development in Tlaxcala. They documented medical cases of thromobocytopenia, leukopenia, anemia and leukemia in the communities allocated in the neighborhood of three industrial corridors affecting children as well as adults [1]; asthma was also documented. Of 16 cases of leukemia, 11 corresponded to teen-agers (11-15 years old). The first report of this kind of ailment dated from 1987 and new cases sporadicaly emerged from 1989 to 1994; from 1996 to date, the occurrence of new cases became more regular, averaging 2 new cases per year in an overall population calculated in 90 000 persons, distributed in 9 communities [1].

A study was done to analyze the quality of the water in the area of the Atoyac river; samples were taken from several discharges of industries that are localized along the river, from several watering channels that are effluents of the river, from natural domestic wells of drinking water, and from the pipeline of potable water. Analyses revealed that the quality of the potable water was in compliance with the norm for potable water for human consumption [2]. On the other side, numerous contaminants including lubricants and oils, soluble and sedimentable solids, as well as biochemical demand of oxygen, in levels that exceeded the mexican environmental norm for residual discharge in national waters, were found in the Atoyac River, in the Xochiac River and in several effluents of both [3, 4]. Futhermore, chlorine and chemical demand of oxygen were found in high concentrations, as well as volatile organic compounds such as chloroform,

methylene chloride and toluene, even though the latter compounds are not considered in the environmental normativity of the country.

Besides the environmental problem, numerous residents of the zone work in the industries where the hygienic conditions do not seem to be adequate to protect workers' health; however, these enterprises would not allow us to interview their workers or inspect the hygienic conditions inside their plants. For this reason we interviewed the people in their own homes in order to construct a picture of the working conditions.

Concern has arisen among the residents in this zone about the deterioration of the environment and the risk to their health and their children's. Hence, in collaboration with the personnel of the Centro Fray Julián Garcés, who are in close contact with these communities, we initiated a study to identify the hazard posed to the health of the population in this area.

MATERIAL AND METHODS

Questionnaire for the identification of potential health hazards

A questionnaire was designed to apply to a samle of the people living in 11 communities where health problems like the abovementioned have been reported. This questionnaire included topics like general health, occupational history, familial antecedents of cancer and diabetes, as well as personal dietary habits, tobacco and alcohol use. Weight and height were recorded to estimate the body mass index. Questions about odors, aspect of the water and general perception of the environment were included. Personnel from the Centro Fray Julián Garcés were trained to apply this questionnaire to 350 persons, one per household. The inquiry covered the towns of: Tepetitla, Villalta, San Mateo Ayecac, San Rafael Tenanyecac, Santiago Michac, Santa Justina Ecatepec, San Lucas Atoyatenco, Santa María Moyotzingo, San Baltazar Temaxcalac, Santa Ana Xalmimilulco and San Francisco Tepeyacac.

Database and analysis

A database was created with the data from the questionnaires. Program Microsoft Access was used to create the database and STATA was used to analyze the data and elaborate tables and graphics.

RESULTS

The questionnaire was oriented at identifying factors that could represent a source of health hazard. It was divided in 4 areas: individual characteristics, diet and habits; health status and familial antecedents of cancer; occupational situation, and source and use of potable water.

Of the 350 questionnaires applied, 45 were not considered for the present analysis, since they belonged to children and teenagers who do not work (17) and the rest were not adequately answered. So the present analysis is based on 305 questionnaires.

Profile of the population, habits and health status

152 males and 153 females answered the questionnaire. The age range was 17 to 86 years old, with a mean of 42.6; weight ranged from 23 to 120 kg; size ranged from 1.4 to 1.9 m and body mass index ranged from 17.9 to 41.3. These measures separated by genre are presented in Table 1.

Smoking and drinking

23.7% of the respondents were smokers, consuming 1 to 10 cigarettes a day. 26% admitted to drink alcohol frequently, however, they did not answer the question about how many glasses they had per week. Only 4 individuals (1.3%) declared to use drugs (Table 2).

Dietary habits and body mass index

As already said, corn and other vegetables are produced in the fields of these communities and they are consumed by the residents, but a great part are transported to the cities of Tlaxcala, Puebla and México. In the farms, there are also animals like porks, cows and poultry, so eggs, meat and milk and derivatives are also produced and consumed by the locals. In spite of this, 11% of the respondents said they do not consume these products.

Body mass index (BMI) is a measure of body fat based on height and weight applied to adults. This factor is important in Toxicology since a great amount of toxicants are highly lipophilic and distribute and concentrate in body fat; this storage lowers the concentration in target organs, however this is dangerous for those with high body mass index when rapid mobilization of fat occurs producing a sudden increase of the toxicant in the blood [5]. BMI values of 18.5-24.9 indicate the range of normality; values under 18.5 indicate that the person is underweight and values greater than 25 to 29.9 indicate overweight [6]. Greater values are considered obesity (Fig. 1).

The data in the sample studied indicate a 1% of underweight people, and 50% of overweight people. Obese persons account to the 10% of the sample (Figure 1). A regression analysis between this parameter and age revealed that they are positively correlated, $p<0.05$.

Chronic health problems

57.7% of all the respondents said they suffered a chronic ailment (Table 3); 47% of them were men, 53% women. Gastritis and digestive problems were more frequently found, followed by anxiety and high pressure. Skin allergies, renal problems and vascular diseases were also frequent. The former and other ailments reported are presented in Table 3.
An attempt was made at finding associations between the chronic ailments described in Table 3 and occupation, and it was found that they are evenly distributed among the 9 occupational groups that were recognized (see Activity and posible exposure to chemicals). However, skin allergies were more frequent among workers in the industry, in the agriculture and laundries (18-27%) compared with housekeepers and office employees (10-14%), although no significant difference was found.

Familial cases of cancer

11 individuals (3%) reported cases of cancer in one of the parents (5), both parents (1), one grandparent (3) and one sibling (2) (Table 4). These persons were not related with one another.

Children with cancer or hematological problems

4 persons reported having one children with leukemia (1.3%), 1 with non-Hodgkin lymphoma (0.3%) and 1, a grandson with hepatic cancer (0.3%) (Table 4). Six persons reported children with thrombocytopenic anemia (2%). Only one child was related with the persons who reported having familial antecedents of cancer. Cases of thrombocytopenic anemia were distributed in San Baltazar Temaxcalac, Villalta and San Mateo Ayecac, two in each. Occupation of the parents was not efficiently assessed, since in the majority of the cases the respondant was the mother and the occupation of the father was not recorded. From this table, a tendency towards an increase in leukemia seems to take place with each generation.

Water management

89% of the respondents obtained the water for domestic use from a communitary well, through a pipeline. 10% use the water of a domestic well and 1 person replied that sometimes they obtained the water from the river. Domestic wells are more frequently used in Sta. Ana Xalmimilulco (36% of the respondents from that town) (Table 5).
The use of containers to store potable water is common in the area; 41.7% of the persons declared to use old containers and of these, 72% did not know their origin (Table 5). Of those who knew the usage of these containers before they took them to store water, said they contained oil, lubricants, disinfectants or belonged to ceramic, adhesive and paper industries;

this kind of containers were more frequently used in San Baltazar Temaxcalac, Sta. Ana Xalmimilulco and San Francisco Tepeyacac.
Commercial potable water was reported to be used by 65% of the respondents in food preparation and for drinking, while 35% never use it.
Finally, 57% said they did not use any method to purify the water, and 23% use chlorine or iodine. 18% boil the water before using it for food preparation and only 2% filter it (Table 5).

Activity and posible exposure to chemicals

Nine categories of occupation could be distinguished: A) at home; B) employees in commerce, education and students; C) industries w/o toxic chemicals, D) ambulant workers; E) seamstresses; F) agriculture; G) industry where toxic chemicals are handled and small mechanical, carpenter, ironsmith shops and plumbers; H) industrial denim laundry. A greater proportion of A and F participated answering the questionnaire (31 and 21% respectively). A,B and C are activities that do not imply an intensive exposure to chemicals. In D were included taxi and truck drivers, ambulant sellers and construction workers who are exposed to sunlight and motor vehicle pollution in the streets. In E were included workers who are exposed to fuzz from the fabrics, either blue denim or other, possibly synthetic ones. Agriculturists (F) are exposed to pesticides, several of which are listed as RESTRICTED in the Official Catalogue of Plaguicides [7], like Tamaron, Gramoxone and Cuproquat, and 2, 4-D. These pesticides contain methamidophos (organophosphate interfering with neuronal transmission), paraquat (neumotoxic) and 2, 4-dichlorophenoxyacetic acid (endocrine disruptor) [8, 9, 10, 11]. Workers in G are exposed to different chemicals like toluene, acid vapors, automotive grease and paints. Finally, workers in laundries (H) are exposed to chlorine bleachers, detergents and dyes of the indigo type and aniline, besides the exposure to intense heat due to the boilers they use to wash and bleach the fabric.
People of groups E to G do not consider that their protective equipment is efficient, since they still can breath and touch or feel the chemicals; no protective equipment is used for the heat and the fuzz.

DISCUSSION

Occupational hazards

A complex situation has been found in the region studied, where several factors are at play. Starting with the hazards at the working place, several situations were brought to our attention about the working conditions in the different industries, particularly the blue denim laundries and

the petrochemical plant where the handling of chemicals like acrilonitrile, benzene, methanol, toluene and many others had taken place since 1990. Even though they use protective equipment to avoid exposure, the workers manifest that vapors and smells are always present even in zones outside the production area. Regretfully, a study could not be made with the workers of the petrochemical plant. Workers in the laundries also described a hazardous situation in locals without good ventilation where the heat of the boilers, combined with the accumulation of vapors from the bleachers and fabric softeners, such as sodium hypochlorite and hydrogen peroxide, result in an irritating atmosphere affecting upper airways, eyes and skin, and in the case of hydrogen peroxide, it can irritate lungs too [12, 13]. These workers use protective equipment only for the skin. An additional hazard is posed to the seamstresses working next to these areas where the bleachers and the heat are produced, due to the fuzz released by the fabrics: minute fibres continuously irritate upper airways and eventually they can also produce lung damage. Two cases of pharynx and bronchial problems due to the continous exposure during 3 years to the fuzz of fabrics in a textile plant were reported in the questionnaires.

Another occupational hazard is found in the agricultural fields. Farmers use several restricted pesticides in very irregular ways: some use them daily, others, once or twice a year. No special equipment is used to apply pesticides, except boots, sometimes gloves. With respect to clothes, they use the same everyday clothes at home and at the field, consisting of blue jeans, long sleeve cotton shirt, thick sole shoes or boots and hat. While working they do not like wearing gloves, because of the heat, so dermal exposure to contaminants in the water is possible. Sun exposure is intense, even though only one case of skin cancer in the face was reported, in a man of more than 60 years old. Farmers are the persons that spend the longest time close to the watering channels and the rivers that are contaminated with the industrial discharges; they breath the vapors of the volatile organic compounds contained in those discharges and are immersed in that air; furthermore, there are areas where they still use the river to irrigate their fields, where they have direct dermal exposure through their hands and a more intense exposure to the volatile organic compounds.

From the occupational situations exposed, the main via of exposure would be the inhalation of toxic chemicals and in a lesser extent, dermal contact and the ingestion of particles adhered to the lips. Table 6 shows the list of toxic chemicals handled in the industry and in the farms of the area. It is important to notice that most of the chemicals reported by our respondents are considered in the Mexican Norm for Security and Hygiene Conditions in the Workplace where the Production, Storage or Handling of Chemical Substances Capable of Contaminating the

Working Place occur. However, those used in the denim laundires like chlorine bleachers and indigo dyes are not considered and the exposure, according to the declaration of workers who participated in the study, is to concentrated vapors of both. It should be said that indigo breaks down into other toxic products and this could occur already in the open environment [14]. Interestingly, chloroform and methylene chloride were not reported by the respondents of the questionnaire; with respect to chloroform, it could be formed in the river after chlorine bleachers are discharged, whereas methylene chloride is used in the adhesive and paint industry, one of which is present in the zone.

Environmental hazards

The Atoyac River at the present is a sewage where people throw their trash. A few farmers still use the water for their cultures, but none of them use this water for their animals or for domestic use. Hence, in spite of the contaminants, most of the people living in the communities in the area would not be in direct contact with the water, since the river is no longer a place for recreation. However, numerous contaminants are volatile and irritating smells are constantly emerging from the river, of chemical origin. The most affected communities, according to their perception of the environment, would be Villalta, San Baltazar Temaxcalac, Santa Ana Xalmimilulco and San Francisco Tepeyacac. Residents of Santa Ana main complain are the laundries, while the other communities refer to the industries in general. A generalized perception are the odors in the rivers Atoyac and Xochiac going from fetid to irritating, causing nausea and headache in San Baltazar and Villalta (Table 7). The Industrial Corridor Quetzalcoatl is located in San Baltazar Temaxcalac; there are textile, metallurgic and car break factories, together with a factory producing aromatic chemicals for the food industry. The Corridor Ixtlacuixtla holds an adhesive production plant and a plant producing automotive electric parts; this corridor is next to the community of Villalta. In the industrial Corridor Huejotzingo there are two textile industries; Sta Ana Xalmimilulco is next to these industries. San Baltazar and Santa María Moyotzingo are the most proximal communities to the petrochemical complex which initiated the industrialization of this former horticultural zone in the decade of 1960. The construction of industrial corridors, however, is more recent; they arrived at the place during 1990 decade.

As with the occupational hazards, exposure to chemicals in the environment are likely to occur via inhalation to organic volatile compounds both from the contaminated rivers and from the burning of trash, as well as to polycyclic aromatic hydrocarbons from kerosene combustion in a water treatment plant. There are exceptions, however, that should be prevented like children

falling in the river by accident, suffering severe skin eruptions or one person who declared they seldomly use this water for domestic cleansing. A list of toxic chemicals detected in the water is given in Table 8.

None of the toxic chemicals listed accumulates in the food chain, even though some of them could reach underground water, like 2,4-D, or accumulate in the sediments, like aniline.

Personal habits and lifestyle

Smoking is a frequent habit and so is drinking. However, people are reluctant at declaring how intense those habits are. Smoking represents a health hazard for lung, throat and hepatic cancer, as well as a health hazard for coronary diseases [15]. Intense drinking (not necessarily alcoholism) contributes to the risk of developing cancer. People who drink too much or abuse drugs may not eat well or take care of themselves, which will increase their overall risk of cancer, in fact, excessive drinkers are 3 times more likely to develop liver cancer than non-drinkers and 4 times more likely to develop esophageal cancer [16].

A risk for cancer has also been documented in relation to BMI, since fat tissue is known to be the storage of numerous lipophilic chemicals. A median of 25.9 value of BMI was found in our survey, which is considered as overweight, and about 20% of the respondents are obese (BMI greater than 30). On the other side, only 3 persons (1%) were underweight in this survey.

Lipophilic chemicals are also a hazard for pregnant women, since they may cross the placenta or get into the mother's milk. Depending upon the stage of pregnancy, exposure of the fetus could result in death or birth defects. If the mother is exposed during lactation, her milk may concentrate certain contaminants, increasing the exposure to her infant [5].

The diet in the area is varied, consisting mainly on the vegetables that are produced in their field; these vegetables are mainly consumed in soups or fried. Consumption of milk and its products is also common. Red meat and chicken are consumed less frequently and supplements, such as vitamins, are not used. This, along with the frequency of gastritis and digestive disorders raises the possibility that there could be a deficiency of vitamin B_{12} consumption and/or absorption in these persons [17]. Vitamin B_{12} is important in the synthesis of 5,10-methylenetetrahydrofolate which is crucial in the formation of dTMP for DNA synthesis. A chronic deficiency is related with pernicious anemia and neurological disorders. At the genetic level, a deficiency causes the substitution of uracil for thymine in the DNA during synthesis, contributing to DNA instability [17]. In a future studies we will approach this possibility of nutrient deficiency in teenagers.

In summary, we were able to identify numerous elements that could contribute to the deterioration of health in the area of study (Table 9). It is probable that the situation could contribute to increase the incidence of thrombocytopenic anemia and of leukemia, both due to occupational exposure and to environmental exposure. The health hazard represented by the presence of chloroform, methylene chloride, toluene and aniline in the industrial discharge onto the Atoyac and Xochiac rivers and effluents, needs to be further characterized by measuring the levels reached in the air by evaporation, wind direction and the fluctuations along the year, in order to assess how these communities will be affected. The occupational situation should also be further studied, since protective measures like the use of equipment and hygienic surveillance according to the mexican norm in the subject [18] do not seem to be adequately covered in any of the hazardous activities identified.

With respect to personal habits like diet, smoking and drinking, campaigns could be organized to stimulate people to consume more fresh fruit and vegetables, as well as supplemented cereals or vitamins in order to protect them against the effects of chemical exposure. An intervention study could be conducted in order to establish whether this strategy could have an impact in the health of these communities, particularly in children and teen-agers who would be more vulnerable to the environmental situation described.

Finally, the volume of work done to in the area has been presented to the Latinamerican Tribunal of the Water who emitted a recommendation to the Industries and the local authorities to take action to protect the health and the environment in the area, implementing the measures necessary to reduce or eliminate the impact that a careless use of the resources is causing in the people's lives.

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REFERENCES

1. Lara Alicia, García Elías, Aguilar Alejo. Casos médicos y estudios biológicos. In: Morales Eduardo (ed.). Ambiente y Derechos Humanos. Centro Fray Julián Garcés, Derechos Humanos y Desarrollo Local A.C. Tlaxcala, Tlax. 2004. Pp. 67-78.
2. NOM-127-SSA1-1994. Secretaría de Salud. Website: http://www.salud.gob.mx Normas.
3. NOM-001-ECOL-1996. Secretaría de Medio Ambiente y Recursos Naturales. Website: http://portal.semarnat.gob.mx/semarnat/portal Leyes y Normas.

4. Navarro I, Flores E, Valladares R. Estudio Ambiental. Informe. In: Morales Eduardo (ed.). Ambiente y Derechos Humanos. Centro Fray Julián Garcés, Derechos Humanos y Desarrollo Local A.C. Tlaxcala, Tlax. 2004. Pp. 27-59.
5. Rozman K and Klaassen C. Absorption, distribution and excretion of toxicants. In: Klaassen C and Watkins J (eds.) Cassarett and Doull's Essentials of Toxicology. McGraw-Hill Medical Publishing Division, USA, 2003. Pp. 59-70.
6. National Heart, Lung and Blood Institute. Obesity Education Initiative. Website: http://nhlbisupport.com/bmi/
7. CICOPLAFEST. Catálogo Oficial de Plaguicidas. Comisión Intersecretarial para el Control del Proceso y uso de Plaguicidas, Fertilizantes y Sustancias Tóxicas. Secretaría de Medio Ambiente, Recursos Naturales y Pesca; Secretaría de Comercio y Fomento Industrial; Secretaría de Agricultura, Ganadería y Desarrollo Rural; Secretaría de Salud. México D.F., 1998.
8. EPA. Pesticides: Organophosphates. Metamidophos Facts. August 2002. Website: http://www.epa.gov/REDs/factsheets/metamidophos_ired_fs.htm
9. NIOSH Pocket Guide to Chemical Hazards, NIOSH Publication No. 2005-151: Paraquat. Website: http://www.cdc.gov/niosh/npg/npgd0478.html
10. CDC Chemical emergencies. Facts About Paraquat. May 2003. Website: http://www.bt.cdc.gov/agent /paraquat/basics/facts.asp
11. EPA Ground Water & Drinking Water. Consumer Factsheet on: 2,4-D. March 2006. Website: http://www.epa.gov/safewater/dwh/c-soc/24-d.html
12. ATSDR-ToxFAQs™. Sodium hydroxide. Website: http://www.atsdr.cdc.gov/tfacts178.html April 2002b.
13. ATSDR-ToxFAQs™. Hydrogen Peroxide. Website: http://www.atsdr.cdc.gov/tfacts174.html April 2002c.
14. Thompson Gale. How products are made-Vol. 6. Website: www.madehow.com/Volume-6/Indigo.html
15. ATSDR Fact Sheet: Cancer. August 30, 2002. Website: http://www.atsdr.cdc.gov/COM/cancer-fs.html.
16. English DR, Holman CDJ, Milne E, Winter MG, Hulse GK, Codde JP, Bower CI Corti B, de Klerk N, Knuiman MW, Kurinczuk JJ, Lewin GF, Ryan GA. The quantification of drug caused morbidity and mortality in Australia, 1995 edition. Commonwealth Department of Human Services and Health, Canberra, 1995.
17. Hugh-Jones NC and Wickramasinghe SN. Macrocytosis and Macrocytic Anaemia. In: Lectures on Haematology, 6th Edition. Blackwell Sci., U.K. 1996. Pp. 96-122.
18. NOM-010-STPS-1993. Secretaría del Trabajo y Previsión Social. Subsecretaría de Previsión Social: Dirección General de Seguridad y Salud en el Trabajo. Website: http://www.stps.gob.mx/ Marco Jurídico.
19. ATSDR-ToxFAQs™. Calcium Hypochlorite/Sodium Hypochlorite. Website: http://www.atsdr.cdc.gov/tfacts184.html April 2002a.
20. ATSDR-ToxFAQs™. Chloroform. Website: http://www.atsdr.cdc.gov/tfacts6.html September 1997.

21. United States Nacional Toxicology Program. Chemical Status Report. NTP Chemtrack System. Research Triangle Park, N.C. November 6, 1990. 482-89-3 Chemical.

22. Rannug U, Bramstedt H, Nilsson U. The presence of geotoxic and bioactive componenets in indigo dyed fabrics-a possible health hazard?. Mutat Res 282(3): 219-225, 1992.

23. Jongen WM. Metabolic activation of promutagenic factors in synthetic indigo by mammalian microsomes. Carcinogenesis 3(11): 1321-1323, 1982.

24. ATSDR-ToxFAQs™. Aniline. Website: http://www.atsdr.cdc.gov/tfacts171.html April 2006.

25. ATSDR-MMG. Medical Management Guidelines. Aniline. Website: http://www.atsdr.cdc.gov/MHMI/mmg171.html November 2005a.

26. ATSDR MMG. Gasoline. Website: http://www.atsdr.cdc.gov/MHMI/mmg72.html November 2005b.

27. ATSDR-ToxFAQs™. Stoddard Solvent. Website: http://www.atsdr.cdc.gov/tfacts79.html September 1996a.

28. ATSDR-ToxFAQs™. Fuel Oils. Website: http://www.atsdr.cdc.gov/tfacts75.html September 1996b.

29. ATSDR-ToxFAQs™. Sulfur trioxide and sulfuric acid. Website: http://www.atsdr.cdc.gov/tfacts117.html June 1999.

30. ATSDR-ToxFAQs™. Acrylonitrile. Website: http://www.atsdr.cdc.gov/tfacts125.html July 1999.

31. ATSDR-ToxFAQs™. Benzene. Website: http://www.atsdr.cdc.gov/tfacts3.html September 2005.

32. NIOSH Pocket Guide to Chemical Hazards, NIOSH Publication No. 2005-151: Methyl alcohol. Website: http://www.cdc.gov/niosh/npg/npgd0397.html

33. ATSDR. Case Studies in Environmental Medicine. Toluene Toxicity. Continuing Education Coordinator, Atlanta, February 2001.

Table 1. Anthropometric data		
	Females	**Males**
Age (years)	40.4 ± 13.8	44.9 ± 16.2
Weight (kg)	63.1 ± 10.0	72.0 ± 11.8
Size (meters)	1.55 ± 0.7	1.66 ± 0.7
Body mass index	26.3 ± 4.0	26.1 ± 3.9

Table 2. Smoking and drinking in the zone	
Habits	**Percentages**
Smoke	23.70
Drink	26.00
There is a correlation between the habit of smoking and the habit of drinking, $p<0.05$	

Table 3. Chronic ailments reported by genre			
Illnesses	**Males %**	**Females %**	**Illnesses**
Gastritis	23.6	24.8	Digestive
Digestive	22.3	20.9	High pressure
Skin allergy	14.4	16.9	Skin allergy
High pressure	12.5	16.4	Vascular
Parasitic infections	9.8	15.6	Anxiety
Weakness	9.8	15.0	Gastritis
Anxiety	8.6	13.0	Renal
Renal	8.5	11.1	Weakness
Diabetes	5.2	7.2	Parasitic infections
Heart	4.6	5.2	Heart
Vascular	4.6	4.5	Liver
Liver	2.6	3.3	Asthma
Pancreas	1.8	3.3	Diabetes
Other allergies	0.9	1.6	Other allergies
Asthma	0.6	1.2	Pancreas
N	152	153	N

Table 4. Familial cases of cancer among respondents of the questionnaire			
Respondents	**Town**	**Ascendants**	**Type of cancer**
1	San Lucas	Father	Skin
2	Tepetitla	Father	Stomach
3	Sta. Justina	Father	Liver
4	Sta. María	Father	Liver
5	Tepetitla	Mother	Cervix
6	San Baltazar	Mother and Father	Skin and leukemia respect.
7	Villalta	Grandmother	Bone
8	Sta. Ana	Grandmother	Stomach
Respondents	**Town**	**Siblings**	**Type of cancer**
9	San Mateo	Sister	Uterus
10	Villalta	Brother	Leukemia
11	Villalta	Cousin	Lymphoma
Respondents	**Town**	**Descendants**	**Type of cancer**
7	Villalta	Daughter	Lymphoma
12	Villalta	Son	Leukemia
13	San Baltazar	Daughter	Leukemia
14	San Baltazar	Son	Leukemia
15	San Baltazar	Daughter	Leukemia
16	Sta. María	Grandson	Liver

Table 5. Management of water for domestic use			
Origin			
Community well	*Domestic well*	*River*	
89%	10%	1%	
Purification system			
None	*Boiling*	*Chlorine or iodide*	*Filter*
62.3%	15.6%	20.5%	1.6%
Storage system			
Tank	*Old containers*		
62%	42% (unknown origin 72%)		

Table 6. toxic chemicals used in the industries of the zone, reported by the respondents								
Industry	**Chemical**	**Most probable exposure vias**	**Toxicity**	**References**	**Mutagenicity**	**Carcinogenicity**	**Food chain incorporation?**	**Regulated by Norm?**
Blue denim laundries	Chlorine bleachers	Dermal and inhalation	Corrosive to skin and muccosae. Chronic exposure causes dermal and airways irritation.	[19]	Chromosomal aberration in human lymphocytes	Not classifiable as carciNogenic in humans (IARC, group 3)	No	No
	Na hydroxide	Dermal and inhalation	Dust and aerosols irritate respiratory airways. Higher doses produce swelling and obstruction. Chronic exposure causes ulceration of nasal passages and skin irritation.	[12]	None	Without information (IARC, group 3)	No	EPA* regulation establishes 2mg/m^3 in the workplace, 8h shift, 40h/week
	H_2O_2	Dermal and inhalation	Vapors of >10% solutions produce severe pulmonary irritation. Eyes suffer ulceration and perforation of cornea. Skin contact causes irritation and bleaching. Concentrated solutions (>3%) cause burns.	[13, 18]	DNA breaks, gene mutation and sister chromatid exchanges	(IARC, group 3)	No	NOM-010-STPS-1993 establishes a level of 1 ppm in the workplace, 8h shift, 40 h/week.
	Indigo	Dermal and inhalation	Dust irritant to the skin, eye and mucous membranes. Several simpler compounds can be produced by decomposing indigo; these compounds include aniline and	[21, 22, 23]	Mutagenic in bacteria	Without information (IARC, group 3)	No	No

Table 6. toxic chemicals used in the industries of the zone, reported by the respondents								
Industry	**Chemical**	**Most probable exposure vias**	**Toxicity**	**References**	**Mutagenicity**	**Carcinogenicity**	**Food chain incorporation?**	**Regulated by Norm?**
			picric acid.					
	Aniline	Dermal and inhalation	Produces methemoglobinemias and hemolytic anemia affecting kidney, heart and liver. Induces Heinz bodies	[18, 24, 25]		Not classifiable as carcinogenic to humans (IARC, group 3)	No	NOM-010-STPS-1993 establishes a level of 2 ppm in the workplace, 8h shift, 40 h/week.
Automotive parts industry and mechanical shops	Gasoline	Dermal and inhalation	Chronic exposure to vapors may affect neuronal function. Children are more susceptible. Produces degreasing dermatitis on prolonged contact.	[26]		Possible carcinogen to humans. (IARC, group 2B)	No	ACGIH* sets a maximum level of 890 mg/m^3 for 8h, 40 h week.
	Thinner	Dermal and inhalation	It causes dizziness and headaches. It causes eye, skin and throat irritation.	[27]	Non conclusive	Not classifiable as carcinogenic in humans (IARC, group 3)	No	NIOSH* established an average level of 60 ppm in 10h shift, 40 h per week.
	Kerosene	Dermal and inhalation	Breathing for short periods the vapors may cause increased blood pressure, loss of appetite and difficulty to concentrate. Long periods causes kidney damage and lowers blood clotting.	[28]		Probably carcinogenic to humans (IARC, group 2A)	No	NIOSH recommends levels Not exceeding 350 mg/m^3 of air, for a 40 h week.

Table 6. toxic chemicals used in the industries of the zone, reported by the respondents								
Industry	**Chemical**	**Most probable exposure vias**	**Toxicity**	**References**	**Mutagenicity**	**Carcinogenicity**	**Food chain incorporation?**	**Regulated by Norm?**
	Sulfuric acid	Dermal and inhalation	Breathing sulfuric acid results in tooth erosion and respiratory tract irritation	[18, 29]		Exposure to strong inorganic acid mists containing sulfuric acid is carciNogenic to humans (IARC, group 1)	No	NOM-010-STPS-1993 establishes a level of 1 mg/m^3 in the workplace, 8h daily, 40 h/week.
Agriculture	Cuproquat and Gramoxone (Paraquat)	Dermal and inhalation	If inhaled, produces poisoning and lung damage. Exposure to concentrated preparations through the skin may lead to poisoning. Persistent exposure leads to lung failure and Parkinson disease.	[9, 10, 18]	Chromosome aberrations, gene mutation and sister chromatid exchanges	Skin cancer (IARC, group 1)	It may contaminate cultures, e.g. it has been detected in marijuana in the USA.	Only authorized people can apply it in the U.S.A. NOM-010-STPS-1993 establishes a level of 0.1mg/m^3 in the workplace, 8h daily, 40 h/week.
	Tamaron	Dermal	Neurotoxic organophospate	[7, 8]	Not in vivo	Probably Not carcinogenic to humans (IARC, group 4)	No	It was listed as restricted from 1995 to 1997 in the Official Catalogue of Plaguicides, CICOPLAFEST.
	2,4-D	Ingestion in the drinking water	Exposure to high levels may affect nervous system, kidneys and liver	[11]	Chromosome aberrations, gene mutation and sister chromatid exchanges	It is being reviewed for Carcinogenicity (IARC, group 3)	It can be incorporated in drinking water.	EPA regulates levels in drinking water with a maximum contaminant level of 70 ppb

Table 6. toxic chemicals used in the industries of the zone, reported by the respondents								
Industry	**Chemical**	**Most probable exposure vias**	**Toxicity**	**References**	**Mutagenicity**	**Carcinogenicity**	**Food chain incorporation?**	**Regulated by Norm?**
Petrochemical plant	Acrilonitrile†	Dermal and inhalation	Neurotoxic and affects lungs	[18, 30]	Sister chromatid exchanges, gene mutations, cell transformation	Probably carcinogenic to humans (IARC, group 2A)	No	NOM-010-STPS-1993 establishes a level of 1ppm in the workplace, 8h daily, 40 h/week.
	Benzene	Inhalation	Chronic exposure causes anemia, haemolisis and immuNosuppression	[18, 31]	Chromosomal aberrations, micronuclei, sister chromatid exchanges, gene mutation, sperm morphology and female fertility.	Induces leucemia (IARC, group 1)	No	NOM-010-STPS-1993 establishes a level of 200 ppm in the workplace, 8h daily, 40 h/week
	Methanol	Dermal and inhalation	Chronic exposure leads to dangerous internal doses by build up, and may cause blindness and death. Metabolism produces formic acid and formaldehyde, which are also toxic.	[18, 32]	Teratogenic	(IARC, group 4)	No	NOM-010-STPS-1993 establishes a level of 2ppm in the workplace, 8h daily, 40 h/week
	Toluene	Dermal, inhalation and ingestion	Neurotoxic and nefrotoxic. High levels may cause death.	[18, 33]	Micronuclei and sister chromatid exchanges	(IARC, group 4)	No	NOM-010-STPS-1993 establishes a level of 50 ppm in the workplace, 8h daily, 40 h/week

* EPA- Environmental Protection Agency (USA); NIOSH- The National Institute for Occupational Safety and Health (USA); ACGIH-American Conference of Industrial Hygienists (USA). † Production stopped in the year 2000.

Table 7. Aspects in the environment perceived as contamination by the inhabitants in the communities

Community	Irritating odors	Agrochemical odors	Fetid odors	Burned kerosene odor	Burning of trash	Odors causing nausea and headache	Laundries	Change of colors in rivers	Toxic wastes	Affected fields	Dust	Use of river water for irrigation	Oxidation pond
1	X	X			X		X	X					
2	X	X	X	X		X		X	X				X
3	X		X				X	X		X		X	
4			X	X			X	X		X			
5		X	X					X				X	
8			X					X				X	X
9	X		X	X	X			X			X		
10	X		X	X						X			
11	X		X	X		X		X	X	X	X		
12	X				X		X	X	X		X		
14	X	X	X		X								

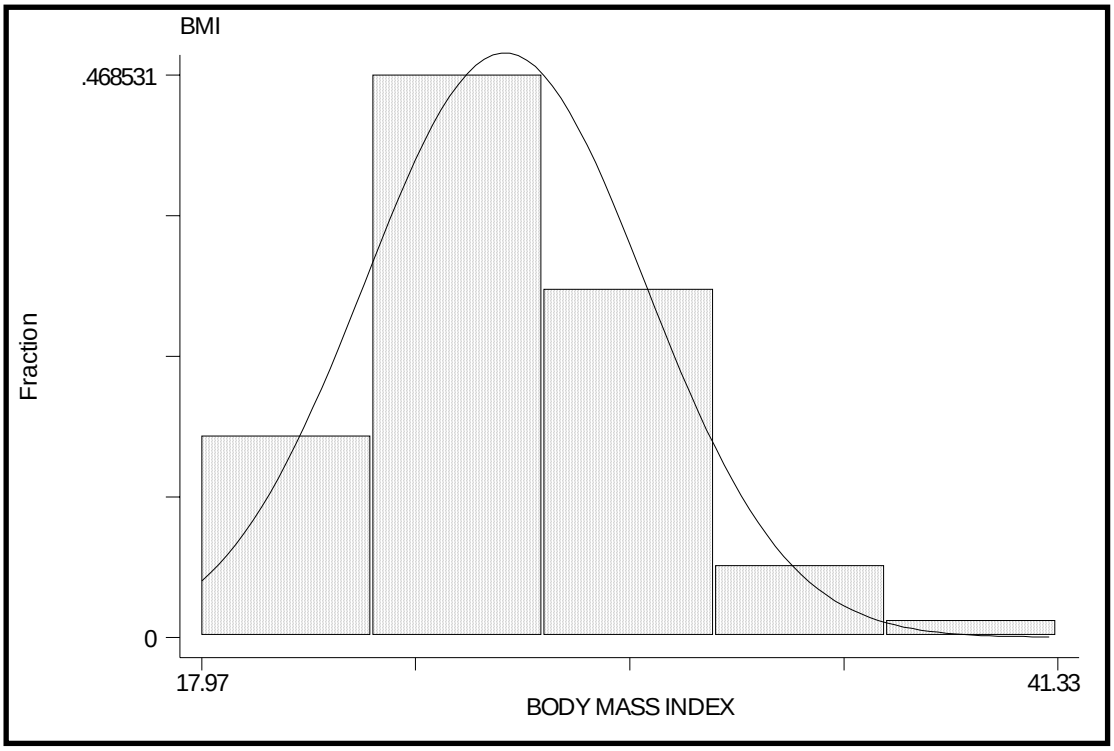
1. Tepetitla, 2. Villalta, 3. San Mateo Ayecac, 4. San Rafael Tenanyecac, 5. Santiago Michac, 8. Santa Justina Ecatepec, 9. San Lucas Atoyatenco, 10. Santa María Moyotzingo, 11. San Baltazar Temaxcalac, 12. Santa Ana Xalmimilulco, 14. San Francisco Tepeyacac.

Table 8. Toxic volatile organic chemicals found in the Atoyac River			
Chemical agent	Characteristics	Is it a human carcinogen?	Environmental norm
Methylene chloride	**Not natural. Industrial solvent, paint remover and metal cleanser. It is easily evaporated into the air and remains as long as 127 days.**	**Probable carcinogenic to humans** (IARC, group 2A)	**There is no norm**
Chloroform	**It is used in the production of other compounds and can be formed in the treatment of water with chlorine. It easily evaporates into the air where it remains for a long time. It also reaches groundwater.**	**Probable carcinogenic to humans** (IARC, group 2A)	**There is no norm**
Toluene	**Is part of the mixture forming oil and gasoline. Widely used in the production of paints, lacquers, adhesives and rubber. It also reaches groundwater.**	**No, it is only neurotoxic and nephrotoxic.** (IARC, group 4)	**There is no norm**
Indigo and aniline	**Natural and synthetic dyes. Aniline vapor is heavier than air and may accumulate in low-lying areas. The vapor is combustible. Aniline has a characteristic aromatic or fishy odor which provides adequate warning of acute exposure. Aniline is rapidly absorbed after inhalation and ingestion. Aniline liquid and vapor are also absorbed well through skin, and this can contribute to systemic toxicity.**	**Aniline is considered a probable carcinogen to humans** (IARC, group 2A)	**There is no norm**

Table 9. Health hazards Identified	
OCCUPATIONAL	• Occupational exposure to toxic and carcinogenic chemicals without adequate protection equipment. Observation of the norm for safety and health in the work environment where dangerous chemicals are handled, produced or stored, might be ignored in several of the industries and in numerous small shops. Another health hazard could be constituted by the fuzz of fabrics, cotton as well as synthetic fabrics, used in the textile industries.
ENVIRONMENTAL	• Probable environmental exposure in the communities closer to the rivers Atoyac and Xochiac due to contaminants present in the rivers, sewages and watering channels. Most likely route of exposure: aerial. The norms for the control of contaminants in discharges to the national water or in the public sewage services are not properly observed by several of the industries and numerous small shops. Some of the contaminants are not regulated in these norms, particularly those referring to indigo and aniline dyes, chlorine bleachers and the byproducts and chemical reactions that can occur once discharged.
INTRINSIC TO THE INDIVIDUAL	• High body mass index • Smokers are also drinkers • Probable deficiency of nutrient intake, namely, folic acid and vitamin B_{12}.

Figure legend.

Fig. 1. Distribution of body mass index in the population of 17 to 86 years old. Median value was 25.93, indicating overweight. BMI was positively correalted with age, $p<0.05$.


BMI
.468531
0
Fraction
17.97
41.33
BODY MASS INDEX