“Yana Curi” Report

The impact of oil development
on the health of the people of the Ecuadorian Amazon

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For all those who fight to defend the land and the people of the Oriente...

"The earth is not dying,
she is being killed.
And the people who are killing her
Have names and addresses."

-U. Utah Philips

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INTRODUCTION

Oil has been and continues to be not only one of the principal sources of income for Ecuador, but also a destructive force on its environment. Since 1972, international oil companies led by Texaco in collaboration with the national company, Petroecuador (previously CEPE), have extracted almost two billion barrels of oil mainly from the region of the Amazon. In this process, millions of gallons of oil and toxic waste have been dumped directly into the environment. Indian communities and farmers, as well as national environmental groups, have spoken out during the past years in clear opposition to the lack of regulation of oil industry development, complaining that the contamination has caused enormous damage to the environment as well as to the health of the people[1].

Despite the evident impact of oil exploitation on the Amazon region's ecosystem, and the potential health risks for the area's inhabitants, there has been no integral chemical study of its impact on the environment,[2] and information about the health effects on residents of these oil-extracting areas is scarce [3]. But the residents are extremely worried about the risk that the contamination poses to their health. The oil companies and the government itself have challenged the affected communities and environmental groups to provide evidence of harmful effects on health in order for them to change their oil-extracting strategies and control contamination.

As a result, the Departamento de Pastoral Social del Vicariato Apostólico of Aguarico, sensitive to the problem and to the concerns of the communities, has begun, in collaboration with the Department of Tropical Medicine and Hygiene of the University of London, to investigate the possible consequences that the oil contamination has on the health of the rural population of the Ecuadorian Amazon.

The two main objectives of this study are:

- increase the limited knowledge that exists about the health effects caused by the contamination surrounding the oil wells.
- answer the questions and concerns of the people of the Oriente about the effects that this contamination has on their health.

This study, called *Yana Curi*[a], begins with an initial report on the risk of cancer that residents of the oil exploitation zones are exposed to. In the months to come, a second report will be published with the results of

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[a] YANA CURI: Quechua for "oil". Literally "Black Gold."

another, more extensive study on the impact of the oil contamination on the health of the people.

The current document is divided into two parts:

- ⇨ the first part briefly presents the problem of oil contamination in the Ecuadorian Amazon and the response of the people of the region to the situation.

- ⇨ the second part examines the case of San Carlos, a town subjected to elevated and continuous exposure to oil contaminants, where a grouping of cancers was discovered. In this section, the development of the investigation of this grouping, the significance of the results, and some final recommendations are presented.

We would like to especially thank Rosa Moreno for her collaboration and hospitality each time we showed up in San Carlos; the departments of statistics of the Society to Fight Cancer (Sociedad de Lucha Contra el Cancer / SOLCA), the Eugenio Espejo Hospital and the Baca Ortiz Hospital for the data they provided, Janet Andrade and Dr. Pepe Yépez, for their interest and help with the various problems that arose while conducting our study; our friends from the associations for health promotion “Sandi Yura” and the Fundación Salud Amazónica for all of their logistic support. Finally, we are grateful to the Spanish non-governmental organization Medicus Mundi Gipúzkoa, which collaborated in the financing of our study.

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[a] YANA CURI: Quechua for “oil”. Literally “Black Gold.”

I. IS THERE CAUSE FOR CONCERN?

Since the start of oil exploitation in the Ecuadorian Oriente, there has been no clear policy for reducing the devastating contamination that it causes. Even the few areas created for the conservation of ecosystems, such as national parks and protected areas, have not been respected by the oil companies[4].

With the development of the oil industry, roads were constructed to make possible the colonization and deforestation of a million hectares of forest. In addition, every day hundreds of oil wells generate more than 4.3 million gallons of toxic waste, which are almost totally unloaded or spilled into the untreated environment. The crude oil, poured regularly on the roads in order to maintain them and to control dust, is scattered throughout the environment by the rain. It is estimated that the cracks in the in the Trans-Ecuadorian Pipeline (Sistema del Oleoducto Trans-Ecuatoriano [SOTE]) have provoked the spilling of 400,000 barrels of oil. These practices contaminate innumerable rivers, streams, and estuaries, often the only sources of water for the inhabitants of this region. Similarly, every day the continuous burning of oil and millions of cubic feet of gas produce highly toxic compounds that contribute to the contamination of the air.

The activities of the oil companies during these years have been characterized by the logic of rapid accumulation with little investment, without taking into account the country's need for energy or natural resources. Obviously this attitude has led to carelessness and disrespect towards environmental, cultural, and socioeconomic issues of the towns and areas where they operate[5].

The companies have defended themselves against these accusations, emphasizing the essential importance of oil for the development of Ecuador and claiming that all of their actions have complied with environmental regulations of the country and that their methods followed "the habitual practices of international industry." They have also sustained that the health problems attributed to this contamination have never been proven[6].

Despite the fact that the Ecuadorian laws and the very Constitution of the Republic guarantee "the right to live in an environment free of contamination," with the State responsible for such protection, until now there has been little or no political action by the different governments to follow the law and establish a system of environmental control over the powerful oil industry[7].

1. The people's response to the situation

From the very beginning, residents of the oil production zones have voiced concerns about the contamination. Farmers and Indians have reported that many local estuaries and rivers, once filled with fish, now lack aquatic life; reports of cattle dying from drinking such water are also frequent. The residents of these zones frequently complain that bathing in these waters causes itchiness and development of rashes on their skin[7,8].

The Indian communities and farmers of the Oriente have repeatedly complained to the different governments and companies about the situation, demanding better quality of life, attention to their basic needs, technical assistance, and above all, cleaning-up of the contamination. But the response of the governments and the oil companies has consisted of "patches" (covering up some of the pools of waste, constructing a school or latrine here and there, opening a path) without confronting the real root of the problem[9,10].

However, in 1991 the publication of the book "Amazon Crude"[2] by the North American Judith Kimerling elevated oil contamination in Ecuador to the status of an international environmental problem. It was the first time that clear evidence was presented to the media, the government, and the oil companies, that supported the claims of the communities. Kimerling showed how oil development can cause a negative impact on the land and the people in each phase of its cycle, from the first seismic studies and drillings to the phases of production and transport.

In 1993, a health promotion association from Sucumbios conducted a study on the effects of oil on health. The study included communities exposed to the contamination and communities where there had been no oil development. The study suggested that the exposed communities had more illnesses, spontaneous abortions, and a higher mortality rate than the communities that were not contaminated[3].

In this same year, a group of Amazon Indians and farmers representing 30,000 affected individuals took legal action in New York against the oil companies, accusing them of irreparable damage to the environment. After several attempts, the lawsuit has been accepted and in the next few months a United States judge will decide if the trial will take place in the U.S. or in Ecuador[10].

In 1994, the Center for Economic and Social Rights[8] published a report documenting the dangerous levels of oil contamination in the rivers of the northern region of the Ecuadorian Oriente. This same report documents numerous skin problems among the local people apparently related to the oil contamination. Consequently, the Ecuadorian government has been accused of violating human rights.

In 1994 the Amazon Defense Front (Frente de Defensa de la Amazonía [FDA]) was created with the participation of numerous organizations of farmers and Indians and local non-governmental organizations (NGOs) with the objective of supervising the trial against Texaco. Since its formation, the group has organized various workshops about the environment, published accusations and reports about oil spills, led community information sessions and organized the visits of government representatives to the contaminated areas, in an intent to open the eyes of the authorities to this disaster.

2. Evidence of the dangers of contamination

According to published information, the risk of adverse effects on health is greatly increased when one is exposed to the contaminants created by oil extraction.

Studies in laboratory animals as well as wild animals show that exposure to oil can cause lesions in various organs, and can provoke birth defects, cancer, and even death.

Different studies on the health effects of oil on humans have demonstrated that the exposed populations face an elevated risk of grave and irreversible illnesses, presenting an important public health problem. The effects can present themselves with different intensity in each of the phases of the oil drilling process: exploration, drilling, production, and transport.

Appendix 1 presents an extensive review of published information on the impact of oil on the health of animals as well as humans.

II. THE CASE OF SAN CARLOS

In October of 1998, the village of San Carlos was visited as a preliminary contact for its inclusion in the study of the impact of oil drilling practices on the health of the people of the Oriente. In the first conversations with the head of nursing at the health center and some residents, the presence of several cases of cancer was observed; they attributed this to elevated and continuous exposure to oil. Through his medical team, the Vicariate of Aguarico decided to carry out an investigation of this potential grouping of cancers.

1. Area of study

San Carlos is a population located about 12 km. from Joya de los Sachas (heading toward Coca) following a road called vía La Parker. San Carlos belongs to Sachas canton, in the province of Orellana. The town is made up of an urban center (70% of the population) surrounded by a rural zone (Precooperative Abdón Calderón).

San Carlos has approximately 1,000 inhabitants. The majority of the population arrived in the 70's following the routes of access opened by the oil companies. Their livelihood is based on agriculture and raising cattle.

The deficient infrastructure of San Carlos does not cover the basic needs of the people. There are no facilities for drinking water and no drainage systems. Only the urban center has electricity, running water, and a health center. The roads are covered with toxic waste.

At the entrance to San Carlos is the pumping station Sacha Sur and more than 30 working wells have been identified in the area. Both the station and the wells eliminate their toxic waste in the estuaries and rivers that cross the town. These same water sources are habitually used by the people of the town for drinking, cooking, bathing, and washing clothing. In Sacha Sur there are four powerful torches that burn gas constantly throughout the day and night. Almost all of the oil wells in San Carlos have been functioning for 20 years[11].

2. How did we conduct the study?

The investigation of this group of cancers was divided into three parts:

- The discovery and confirmation of cases which occurred during the last ten years, 1989-1998;

- The calculation of the standard cancer rate in the area of study; this calculation permits us to detect if there is an excess incidence of cancer beyond the expected rate.

- The investigation of possible contamination of water in the area.

2.1 Discovery and confirmation of cases

The first step in this study was to determine how many cases of cancer had occurred in San Carlos, where they had occurred, and when.

Thanks to the collaboration of the head of the local infirmary, a list was created with the names, ages, time of residence and place of diagnosis of all possible cases of cancer in the past ten years, those who had died as well as those who had survived. Then the registers of the hospitals where the patients had been cared for were consulted in order to confirm the diagnosis of cancer.

From an initial list of 18 names, after confirming the definitive diagnosis, we were left with ten cases of cancer (there is one more probable case, but the diagnosis has not yet been confirmed). The hospitals were: SOLCA (6 patients), Eugenio Espejo Hospital(3), and Baca Ortiz hospital (1). For each patient, these institutions provided the age, place of residence, date of diagnosis, and type of cancer.

2.2 Calculation of the standard cancer rate.

Once the diagnoses were confirmed, the objective was to determine if the number of cancers found represented a normal occurrence or a true excess. To find out, the standard cancer rate (SCR) was calculated.

In order to calculate the SCR, it is necessary to know not only the number of cancers in San Carlos, but also the following information:

- The population of San Carlos; since there had not been an official census of the population of San Carlos for the period 1989-1998, an estimate of the census was used based on the distribution of the population of La Joya de los Sachas canton[12] and on data collected in San Carlos as part of the present study. (See Appendix 3). In order to simplify the calculation, the annual census of San Carlos during the period 1989-1998 was assumed to be constant. As we stated earlier, the total population of San Carlos for 1998 was estimated at 1,000 inhabitants (Table 1).

- The rate of cancers in a reference population; in this case we decided that our reference population would be Quito, a city with adequate information on cancer through the National Tumor Registry (Registro Nacional de Tumores RNT). The RNT provides information on the incidence of cancer in the population of Quito, divided by age and sex, for the period 1985-1996[13].

- Finally, the SCR is calculated by dividing the number of observed cancers (O) in San Carlos during this 10-year period by the number of expected cancers (E) according to the rates of the reference population, in this case Quito (O/E). The calculation of the SCR is explained in Appendix 2.

Table 1. Estimated age distribution of the population of San Carlos, 1998.

Age	Men	Women	Total
0-4	94	77	171
5-14	165	135	300
15-44	233	191	424
45-64	46	38	84
>65	12	9	21
TOTAL	550	450	1000

2.3 Evaluation of the environment

In order to evaluate the extent to which the people of San Carlos were exposed to contamination, samples of water were collected from the areas used by the community to supply drinking water, and water for cooking, bathing, and washing clothes. The analysis of the samples included total hydrocarbons (HT) and was conducted in the water and soil laboratory of the P. Miguel Gamboa School, in Coca.

The method for measuring the HT required extraction with 1.1.2-trichloro-trifloro-ethane and determination by infra-red spectophotometry. The exact origin of the water samples was hidden from the laboratory investigators in order to avoid subjectivity in the interpretation of the results.

Because of the lack of economic and technical resources, an evaluation of the soil and the air in these zones was not possible.

3. What were the results?

3.1 Discovery and confirmation of cases.

Ten patients with cancer were found in San Carlos during the period from 1989-1998. Of these 10 cases, 3 suffered from stomach cancer; this number represents almost 40% of the cancers which we consider those only found in males. The rest of the cancers were of the larynx (1), liver (1), a melanoma (a type of skin cancer), bile duct (1), cervix (1), a lymphoma (a cancer of the lymphatic ganglions) and leukemia (a cancer of the white blood cells). Almost all of the cases of cancer found where diagnosed in males (80%). The characteristics of the patients and the tumors are outlined in Table 2.

Sixty percent of the cancers were diagnosed in the last 3 years. The age in which the cancers were diagnosed ranged from 5 to 86 years. Of the 10 patients diagnosed with cancer, 6 have died (another patient died in April of this year); the majority of these deaths took place a short time after diagnosis which could suggest either the aggressive nature of the cancer or the delay of the patients in seeking medical help. The patients' time of residence in San Carlos ranged from 7 to 30 years, with an average time of 17 years.

Table 2. Cases of cancer discovered in San Carlos, Orellana, 1989-1998.

ICD[a]	SEX	TYPE of CANCER	DATE of DIAGNOSIS	AGE at DIAGNOSIS	DATE of DEATH
C24	M	Bile duct[b]	March 89	68	July 89
C16	M	Stomach	June 91	64	July 92
C16	M	Stomach	August 92	55	Sept. 92
C16	M	Stomach	June 97	65	Oct. 98
C32	M	Larynx	Sept. 97	46	-
C22	M	Liver	August 98	86	Sept. 98
172	M	Melanoma	Nov. 96	52	Aug. 97
C42	M	Leukemia[c]	July 93	5	-
C77	F	Lymphoma[d]	July 96	28	April 99
C53	F	Cervix	May 98	52	-

[a] ICD: International Classification of Diseases.
[b] Others unspecified of the biliar system
[c] Acute lymphoblastic leukemia
[d] Non-Hodgkins lymphoma

3.2 Determination of the standard rate of cancers.

The results of the calculations of the SCR, adjusted according to age, are presented in Table 3. Considering all of the cancer cases, an excess of cancer was found in the male population (8 observed compared to 3.5 expected). This suggests a risk in this population 2.3 times the expected rate, or an excess risk of 130%. Depending on the type of cancer, the male population of San Carlos presents a risk 30 times higher than expected for developing cancer of the larynx; 18 times higher for bile duct cancer; 15 times higher for liver cancer and melanoma, 4.6 times higher for stomach cancer, and 2.6 times higher for leukemia. All of these cancers, except leukemia, are also statistically significant.[c] In women, after all cancers were considered, an overall excess was not found. However, the risk of lymphoma is 6.7 times higher than expected and the risk of cervical cancer is 2.3 times higher.

[c] Statistically significant: indicates that there is higher than 95% probability that the obtained results are not due to chance.

Table 3. Incidence of cancer in San Carlos, 1998 (O= number of observed cancers; E= number of expected cancers; SCR=standard cancer rate; CI 95%= confidence interval of 95%).

CANCER	MEN				WOMEN			
	O	E	SCR	CI 95%	O	E	SCR	CI 95%
Stomach	3	0.64	4.64	1.5-14.4	-	-	-	-
Larynx	1	0.03	29.9	4.2-212.5	-	-	-	-
Bile duct	1	0.05	18	2.5-127.9	-	-	-	-
Liver	1	0.06	14.5	2-102.7	-	-	-	-
Melanoma	1	0.06	15.2	2.1-107.7	-	-	-	-
Leukemia	1	0.37	2.65	0.3-18.8	-	-	-	-
Lymphoma		-	-	-	1	0.14	6.7	0.9-47.5
Cervix		-	-	-	1	0.43	2.3	0.3-16.2
TOTAL [a]	8	3.5	2.3	1.1-4.5	2	4	0.5	0.12-1.9

[a] Calculations done with incidence rates of all cancers except skin cancer (C44)

Due to the fact that the majority of the men with cancer had died, using the same method, the number of expected deaths in San Carlos due to cancer was calculated and compared with the number observed deaths. The results of these calculations are presented in Table 4. When total cancers were considered, the number of deaths observed in San Carlos was much higher than the expected rate (6 observed, 1.6 expected). If we divide the results for the different types of cancer, the risk of mortality from stomach cancer is 8 times higher in San Carlos than in Quito, liver cancer mortality is 21 times higher, bile duct cancer mortality is 26.5 times higher, and melanoma mortality is 70 times higher. As stated earlier, this data either suggests the aggressive nature of these tumors or reflects the difficulty posed to the people of San Carlos because of the lack of access to hospitals where they can obtain an early diagnosis.

Table 4. Incidence of cancer mortality in San Carlos, 1998 (O= number of observed cancers; E= number of expected cancers; SCR= standard cancer rate; CI 95%= confidence interval of 95%).

CANCER	MEN			
	O	E	SCR	CI 95%
Stomach	3	0.36	8.21	2.65-25.46
Liver	1	0.046	21.33	3-151.44
Melanoma	1	0.0014	69.74	9.82-495.07
Bile duct	6	0.037	26.57	3.74-188.66
TOTAL[a]		1.67	3.59	1.61-7.99

[a] Calculations done with incidence rates of all cancers except skin cancer (C44)

3.3 Evaluation of the environment

The main river that runs through San Carlos is the Huamayacu river. The people use the water of this river for bathing, washing clothing, drinking, and also fishing. In the areas surrounding San Carlos are the Basura river, the Parker river, and other small rivers which are also used by the people of the town. During the month of March 1999, samples were taken from the Huamayacu, Basura, and Parker rivers, and from the Iniap estuary. The samples were taken in the wintertime when there was no visible waste in the rivers. The results are presented in Table 5.

In the Iniap estuaries, the concentration of hydrocarbons was more than 10 times the level permitted by the regulations of the European Community, the concentration was 53 times higher in the Parker river, 144 times higher in the Huamayacu, and in the Basura the concentration of hydrocarbons was 288 times the acceptable limit for drinking water.

In the 1994 study conducted by the CDES[8], high levels of contamination from aromatic polycyclic hydrocarbons were found in the rivers which originate from the Sacha Central pumping station and run through San Carlos.

These data further demonstrate the extent to which the residents of this town are exposed to oil contaminants greatly exceeding internationally recognized safety limits, and how this exposure persists throughout the years.

Table 5. Concentration of total hydrocarbons (TH)[a] in the rivers of San Carlos, 1999.

IDENTIFICATION	TOTAL HYDROCARBONS
Parker River	0.53
Huamayacu River	1.444
Basura River	2.888
Iniap estuary	0.097

[a] The limit of hydrocarbons permitted in drinking water according to regulations of the European Community is 0.01 parts per million (ppm).

4. What is the significance of these results?

This study has shown that the population of San Carlos is subjected to a much higher risk of developing cancer than should be expected based on the characteristics of the population.

The risk in males is particularly high for cancer of the larynx, bile ducts, liver, stomach, melanoma, and leukemia. It is also important to point out the high risk of dying from cancer in this population, especially from cancer of the stomach, liver, bile duct, and melanoma.

In women, an excess risk of cervical cancer and lymphoma has been observed.

It is suspected that the excess risk of cancer is due to continuous and persistent contamination of the environment by toxins from oil development in the area. This potential association between the occurrence of cancer in San Carlos and the exposure to chemicals from oil wells is supported by the following facts:

1. The high rate of cancer found.
The risk of developing certain types of cancer in this population is high enough to suspect the presence of some factor which is contributing to the abnormal elevation.

2. Length of residence
The extended time of residence of patients in the area of study implies a possible environmental carcinogenic[d] because of the long latency period required by most known carcinogens. This fact is supported by the finding that more than half of the cancers were diagnosed in the last 3 years.

3. Length of exposure
The association between incidence of cancer and oil contamination is supported by the long history of exposure to oil toxins which the people of San Carlos have suffered. There have been many complaints from residents about oil spills during these twenty years of oil development[8,11].

4. The carcinogenic effects of the chemicals.

[d] Carcinogenic: any biological element capable of triggering the process of cancer formation.

It is well known that crude oil and toxic waste from oil stations and wells are highly carcinogenic[8]. A study conducted on workers in oil fields[14] showed an excess of leukemia, and numerous studies conducted on residents near petrochemistry industries have demonstrated an excess in the rate of cancer incidence and cancer mortality[15,16,17]. However, no study to date had investigated the relationship between cancer incidence and the residence in areas of oil exploitation.

5. Absence of other risk factors.

The affected population lacks one of the most common risk factors for cancer: tobacco. As this is a rural population, it also maintains a healthy diet based mainly on the consumption of rice, yuca, plátano, meat (poultry, beef, pork) and occasionally fish, which lowers the risk of cancer. In addition, the population of Quito has also been subjected to the risk of cancer from urban contamination, which would further increase the difference between both populations if we were to eliminate this risk factor.

Furthermore, there are no other industries in the area, aside from the oil industry, which could release cancer-causing toxins.

6. The types of cancers found.

The majority of cancers found can be explained by the type of exposure that the population has been subjected to. The routes of exposure to toxins released by oil activity mainly include the water and the air. Exposure by way of the air includes migration of the gases from the burning of petroleum and crude oil in wells and stations as well as emission from pools of waste and oil roads. The water route includes contamination of surface water and of underground wells, which causes the contamination of water used domestically by the people. The contamination of the air, water, or land could also affect the consumption of agricultural products and meat.

Some of the possible limitations of this study include:

1. The inexactitude of the census of San Carlos, which could cause an imprecise calculation of the expected cancer rate. However, the estimated census of San Carlos was high in order to avoid this type of problem.
2. The reduced number of cases of this grouping of cancers does not permit statistically more convincing analysis that could put in evidence other types of significant differences, which is reflected in the high confidence intervals

3. The possibility of having a greater number of cancer cases in San Carlos which have not been diagnosed because access to adequate medical centers for the residents is difficult.
4. The migration of the population could cause a different number of observed cases since individuals with cancer may have moved to other regions. However, if this had occurred, the number of cancers in the San Carlos would be even higher.
5. As with other studies on health and the environment, there is the problem of socioeconomic factors which vary between the areas compared, altering the association between cancer and variable exposure. However, it was not possible to obtain adequate socioeconomic data on the two populations.

5. Some final recommendations

1. More in-depth studies of cohorts and/or case controls are necessary to confirm the association and obtain more precise information on the risk factors which could be producing the high rate of cancers found in this population.
2. A more extensive study in the area in order to adequately detect all of the possible sources of contamination, eliminate them and establish an adequate monitoring system in the area. As long as the oil contamination persists, the health of this and similar populations will continue to be seriously threatened.
3. Due to the grave nature of cancer, it would be useful to establish an epidemiological monitoring system for the illness which would permit a better understanding of its distribution and its risk factors with the goal of establishing adequate prevention programs.

APPENDIX 1

What is known about the impact of oil on health?

There are two principal sources of information that can be used to evaluate the health risks of any population exposed to chemicals. The first are studies of toxicity using laboratory animals and the second, studies in human populations.[18]

Numerous studies have established that the exposure of animals and humans to oil or its components can result in acute health effects (such as skin problems) or even deathly diseases (such as cancer)[8]. In this appendix we present a bibliographic review of the effects of oil contamination on animals and humans.

1. Studies on animals

1.1 Laboratory animals

Toxic effects. Studies in birds have shown that ingestion of oil reduces red blood cells as well as white blood cells in primary[19] lymphatic organs. The administration of crude oil has also resulted in functional changes in hepatic cells of rats[20] and inhibition of testicular development in salmon[21]. The effects of crude oil produced from the burning of petroleum in Kuwait resulted in diminished survival and growth of the marine fish *Menidia beryllina.*[22]

Cancer. Numerous studies report skin tumors in rats following the application of crude oil[23-24].

Effects on reproduction. The oral administration of crude oil to pregnant rats reduced the weight and length of the fetus and multiple exposure considerably diminished the mother's weight. Several studies have also demonstrated the pronounced effect of crude oil on the reproductive capacity of birds after its application to the surface of the egg or after oral administration[27-30].

1.2 Wild animals

Fish. Different studies conducted in marine areas have shown the presence of crude oil in different species of fish following oil spills[31,32]. The implication of these contaminants for the ecosystems and for the population dependent on them is still not clear.

Birds. There is sufficient evidence that oil spills are responsible for massive deaths of marine birds[33,34] and the occurrence of hemolytic anemia has been observed in ducks after the ingestion of crude oil[35].

Mammals. Significant differences in weight and in blood hemoglobin levels occurred in otters inhabiting the contaminated and non-contaminated areas of Prince William Sound (Alaska) after the ExxonValdez oil spill in 1989. An increase in the mortality of seals has also been reported following the oil spills in the North Sea[36].

In areas of oil production, the proximity of cattle to the drilling and production sites often results in poisoning of the animals from ingestion of crude oil, salt water, heavy metals, and caustic chemicals. The most common cause of illness or death following the exposure to oil particles is pneumonia from breathing it in, which can cause a chronic deterioration of health, with death occurring after several days or weeks[37,38].

2. Studies on humans

Oil production can negatively infringe upon the health of the population in every phase of its cycle. In this section, due to its implications for the area of study, its impact on health is described in relation to the initial seismic studies, drilling, production, and finally transport.

In addition, oil exposure is not limited to the areas close to the contamination. When oil contaminates the environment, the heaviest particles tend to be deposited in the sediment from where they can repeatedly contaminate water sources or be consumed by organisms that can enter the human food chain. Lighter oil components can evaporate within hours and be deposited by air or water at great distances from where they were produced[8].

Oil or its components can enter into contact with the human body in three ways:

- absorption through the skin

- ingestion of food and water
- inhalation of oil and its gases

The inhabitants of oil production areas of the Oriente are faced with potential exposure by any of these three routes.

2.1 Exploration phase

We have not found literature about the health effects during this phase. However, in the context of Ecuador, exploration workers have reported low salaries and poor conditions of life and work; illnesses related to the work as well as skin diseases and gastrointestinal diseases are frequent[39].

Yellow fever was contracted by many workers (one died) due to penetration into the jungle without adequate protection with the vaccine (personal observation).

Many workers are Indians and their entrance into this world of migratory work has severed traditional family life and sparked epidemics of influenza, malaria, hepatitis, and venereal diseases in their communities (Amunárriz, personal communication).

2.2 Drilling / Production phase

Activities associated with this phase produce a great variety of contaminants in the soil, the water, and the air. The communities that live close to the oil wells have a greater probability of suffering exposure to chemicals and toxins when they breathe, use water for drinking, bathing, or cooking, and eat food that has been in contact with the toxins.

The contaminants of crude oil can be deposited in the earth or ingested through aquatic organisms in quantities that can have adverse effects on health and increase rates of malnutrition, especially in children and fishermen, when contaminated fish or their products enter the food chain[40].

Sathiakumar *et al.*[14] conducted an epidemiological study on oil and gas field workers and found an association between their work and acute myeloid leukemia.

The drilling and production phases also carry the risk of accidents[41]. Furthermore, the oil industry exposes workers to high levels of noise from drills, compressors, generators, etc.[42]

Currently, three groups of chemical exposure merit a more detailed explanation.

2.2.1. Crude oil

Crude oil has been defined as a complex mixture, composed primarily of paraphenol, aromatic hydrocarbons, and particles of other elements including various metals. Among the identified components of crude oil, the aromatic hydrocarbons of toxicological interest are alka-benzols (mainly toluene and xylene) and the polynuclear aromatic hydrocarbons[43].

The effects of acute exposure to crude oil on humans are usually transient and of short duration unless the concentration of the components is unusually high. Such exposures irritate the skin, cause itchiness or irritation of the eyes from accidental contact or exposure to the vapors, and can cause nausea, vertigo, headache, or dizziness from prolonged or repeated exposure to low concentrations of its volatile components[44]. Inhalation of mineral oils can cause lipoid pneumonia and death[45].

Of particular concern is exposure to benzene, toluene and xylene. High concentrations of benzene cause neurotoxic symptoms, and a prolonged exposure to toxic levels can cause lesions of the bone marrow[46]. The primary effects of toluene and xylene are on the central nervous system. There is not sufficient data on the incidence of cancer following human exposure to these toxins. There is also no evidence of birth defects due to benzene, toluene, or xylene.[44]

Due to its elevated carcinogenic effects and long persistance in the environment, benzopyrene seems to be the most important risk factor and most relevant indicator of crude oil contamination. Adequate data on which to base a quantitative evaluation on the risk of cancer following the ingestion of HAP are only available for BaP[47,48].

There is little information available about the oral toxicity of the HAPs, especially after exposure of long duration.

2.2.2. Other chemical exposure

The oil companies in Ecuador have not informed the public of the chemical data related to waste from oil drilling. Data from the U.S. show that the waste from drilling can contain significant quantities of a wide variety of contaminants such as antimony, arsenic, cadmium, chrome, lead, magnesium, zinc, benzene and other hydrocarbons as well as toxic levels of sodium and chloride[2].

The heavy metals which pose a threat to health from oil exposure through drinking water are mercury and cadmium. Exposure to mercury occurs through contaminated surface water or underground water or from fish consumption[49]. Similarly, the components of alka-mercury are liposoluble and volatile; therefore they carry the risk of being absorbed by the skin or inhaled when bathing in contaminated waters[50]. The most common symptoms from mercury poisoning are disordered thinking, difficulty walking and talking, tunnel vision, and difficulty chewing and swallowing[51]. The toxicological implications of exposure to low concentrations of mercury are still not well understood.

Cadmium accumulates throughout one's life. Environmental exposure to cadmium can occur, as in the case of mercury, through water or food consumption. Individuals in Japan who consumed rice contaminated with cadmium developed chronic cadmium poisoning and a reduced life expectancy[52]. Elevated consumption of cadmium produces nausea, vomiting, abdominal pain, diarrhea, and renal disease. Recent studies have suggested an increase in lung cancer mortality in workers exposed to cadmium[54]. Other studies have also indicated an association between the level of cadmium in drinking water and prostate cancer.[55]

2.2.3. Air contamination

Air contamination with chemical or solid agents is one of the consequences of drilling oil. The degree to which the contaminants emitted into the air contain a risk for the general population depends on various factors; some of these include the type and quantity of compounds released, the condition of the atmosphere, the number of people exposed and their susceptibility.

The burning of oil and gas contaminates the air with oxides of nitrogen, sulfur, and carbon (CO), as well as with heavy metals , hydrocarbons and diverse particles of carbon. Many of these emissions are toxic, and the oxides of nitrogen can react with solar light to form ozone, an irritant to the human respiratory tract.

Although quantitative data on air emissions from oil operations are not available in Ecuador – at least to the public- an internal study by Petroecuador found that the levels of contaminated air were alarming[2].

Numerous studies have demonstrated the relationship between exposure to these contaminants and bronco-constrictive effects[56], documenting asthmatic responses in adults as well as in children[57]. Other studies have also associated an increase in mortality with air contamination[58,59].

Investigations of the exposure to ozone and nitrogen dioxide have revealed symptoms and changes in respiratory mechanisms, bronco-constriction and pulmonary edema[60]. The clinical effects of acute carbon poisoning vary with the level of intoxication, from non-specific symptoms (headache, dizziness, fatigue) to death[61]. Chronic exposure to carbon, at low doses, can affect the coagulation system increasing the risk of thromboembolism in the heart or brain[62].

Along with these contaminants, the populations exposed to HAP and volatile organic compounds in the air are at risk for lung cancer[63] and adverse respiratory effects[64] respectively.

2.3 Transport

The accumulation of water during the construction of roads is inevitable. Mosquitoes carrying malaria proliferate in these surface waters, increasing the spread of the disease. In 1974, more the 50% of the malaria of the Brazilian Amazon was associated with the narrow area of influence of the Trans-Amazon highway[65].

Many of the roads of the Oriente are without asphalt and great quantities of dust from traffic can cause respiratory diseases[66]. Where the roads are covered with crude oil, there is often an intense odor, and skin problems occur when people walk barefoot.

There also seems to be a strong association between this development and the mortality related to vehicles[67]. On the roads of the Oriente, car accidents are numerous, and are becoming the second highest cause of mortality in small cities[68].

2.4 Oil spills

Epidemiological investigations of the great oil spills have not been frequently carried out and have concentrated more on workers involved in the clean-up operations than on the residents of the areas. These studies have also only been carried out long after the incidents occurred[69].

One study conducted a year after the 1989 Exxon Valdez oil spill off the coast of Alaska suggested an increase in anxiety attacks, post-traumatic stress disorder, and depressive symptoms in the affected communities after the spill. The populations most at risk for these conditions were women and Indians[70].

Another study evaluating the immediate and posterior effects on health after the oil spill of the Braer tanker off the coast of Shetland (United Kingdom) was conducted in 1993; anecdotal reports of acute symptoms without significant differences were found in the exposed population during the initial phase of study and no differences in the health of the exposed population and the non-contaminated population were found 6 months later[44,71].

APPENDIX 2

Calculation of the standard rate of cancer incidence by age and sex

The standard cancer rate (SCR) is calculated by dividing the number of observed cancer cases in the study population by the number of expected cancers in the same population. To determine the number of expected cancers, the number of person/years corresponding to the age distribution of the study population is multiplied by the cancer rate of the reference population corresponding to the same age distribution.

The age-adjusted calculation of the SCR is illustrated below for tumors of the larynx.

AGE GROUP	OBSERVED CANCER	STANDARD RATE (100,000)	POPULATION/ YEARS	EXPECTED CANCER
0-4	-	0	940	0
5-9	-	0	900	0
10-14	-	0	750	0
15-19	-	0	580	0
20-24	-	0	470	0
25-29	-	0	400	0
30-34	-	0	330	0
35-39	-	0.4	320	0.00128
40-44	-	1.1	230	0.00253
45-49	1	0.8	160	0.00128
50-54	-	1.5	140	0.00210
55-59	-	5.1	90	0.00459
60-64	-	6.9	70	0.00483
65-69	-	4.2	40	0.00168
70-74	-	12.9	30	0.00387
>75	-	22.5	50	0.01125
	1			**0.03341**

SCR = Observed/Expected = 1/0.03341 = **29.93**

APPENDIX 3

Estimated distribution of the population[a] of San Carlos by age groups.

MALE POPULATION: 550
FEMALE POPULATION: 450

AGE GROUP	%	MALES	FEMALES
0-4	17	94	77
5-9	16.4	90	74
10-14	13.5	75	61
15-19	10.4	58	47
20-24	8.6	47	39
25-29	7.2	40	33
30-34	5.9	33	27
35-39	5.7	32	26
40-44	4.2	23	19
45-49	2.9	16	13
50-54	2.6	14	12
55-59	1.6	9	7
60-64	1.2	7	6
65-69	0.76	4	3
70-74	0.58	3	2
>75	0.83	5	4
TOTAL		550	450

[a] The percentage of the population is based on estimates of the National Institute of Statistics and Census for the rural population of Joya de los Sachas for the year 1998

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