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Impact of Crude Oil Exploration on Environment and Humans: A Case Profile of Kumchai EPS (Early Production System) and Drilling Sites of Changlang District in Arunachal Pradesh

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Abstract

Emerging global energy crisis led to unconventional oil and gas drilling, exploration and production. The application of fracking, the standard procedure for crude oil exploration, has a high potential to cause environmental pollution. Fracking entails injecting large volumes of water, sand and chemical compound mixtures, particulate matter (PM), nitric oxides (NOx), methanol, naphthalene, xylene, toluene, ethylbenzene, formaldehyde, sulfuric acid etc. (many of which are toxic and carcinogenic), into a drilled well at high pressure to break up the shale rocks and release natural gas. Because of this injection process and the noise associated with the drilling and processing of the shale rock, two areas of concern surround non-traditional gas industry sites: the contamination of the water, soil, and air caused by the injection process, and the high levels of noise generated by the development and drilling process.

Besides these, methane gas emission and wastage, benzene, ethylbenzene, toluene, and three isomers of xylene (a group of contaminants) are found in crude oil, coal, and gas deposits. This group is of recent interest because of its reported presence in drinking water wells in fracking areas. In this paper we explore the plausible impact of Kumchai eps (early production system) and drilling sites of Changlang district in Arunachal Pradesh, to environment and humans. Even though, the exploration sites have an Environmental Impact Assessment study by Environmental Resource Management in 2019 and feasibility report 2020, we hereby report ground field-study profile, which in the long run will help mitigate some of the adverse impacts and provide clues for further scientific studies, without stalling the production.

Keywords: Fracking, Drilling, Noise, Chemical mixtures, Pollution.

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Introduction

Humankind depends on fossil fuels since time immemorial. Crude oil and petroleum are also fossil fuels as they are formed from the plants and animals that lived millions of years ago. With the advent of industrial revolution, massive urban expansion, exponential growth of automobile factories/units and to deal with the global energy crisis, one of the many indispensable anthropogenic factors closely associated with decadence of environment is the unconventional oil and gas drilling technique, exploration and production.

Hydraulic fracturing (fracking) together with horizontal drilling is a standard technique used to access gas and oil trapped in shale rock beds, widely applied in developed countries like the United States where it has been used industrially since 1949 and has generated great economic benefits. In recent years fracking has spread to other countries where technically recoverable gas reserves have been estimated, including countries in the Latin American region such as Mexico, Venezuela, Colombia, Brazil, Paraguay and Argentina. Several publications point out that the application of fracking has a high potential to cause environmental pollution; it is mainly accused of producing noise (Richburg & Slagley, 2019), facilitating the surface emission of subsurface gases (Weinhold, 2012), polluting the air (Cotton, Rattle, & Alstine, 2014) and generating water and soil contamination by extraction wastewater lagoons.

However, only since, 2013 have some scientific studies, reported evidence of contamination in areas where the technique has been developed. (Howarth, 2019) and (Paulik, Hobbie, & Rohlman, 2018). In the wake of such limited studies, an impromptu question which arises is: What physical and chemical risk events related to the application of the fracking technique and horizontal drilling are documented in recent scientific literature? Is there any study related to drilling, extraction and production of crude oil in Changlang district of Arunachal? The answers to these questions are intended to shed light on the possible environmental impact of fracking.

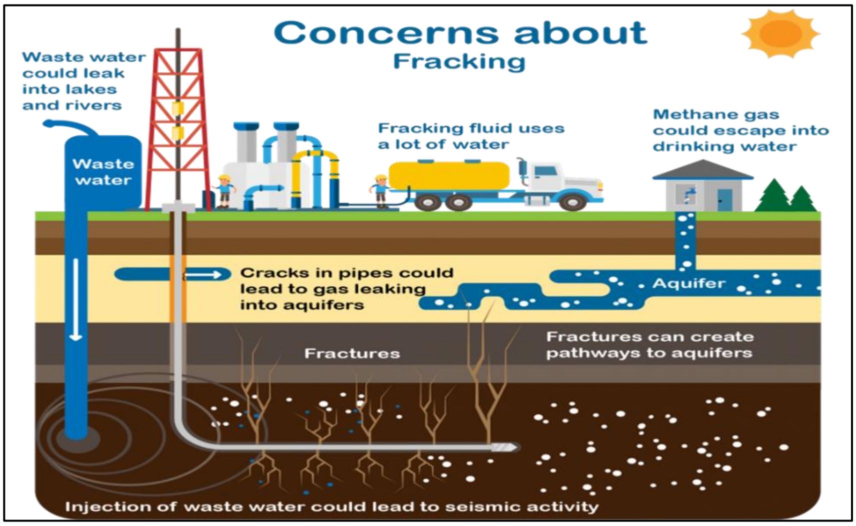
Exploration know-how and its concern

Exploration of crude oil consists of drilling and extraction. Hydraulic fracturing (fracking) together with horizontal drilling, as mentioned above is the standard procedure. Fracking entails injecting large volumes of water, sand and chemical compound mixtures particulate matter (PM), nitric oxides (NO_x), methanol, naphthalene, xylene, toluene, ethylbenzene, formaldehyde, sulfuric acid etc. (many of which are toxic and carcinogenic), into a drilled well at high pressure to break up the shale rocks and release natural gas. Because of this injection process and the noise associated with the drilling and processing of the shale rock, two areas of concern surround non-traditional gas industry sites: the contamination of the water, soil, and air caused by the injection process, and the high levels of noise generated by the development and drilling process (Richburg & Slagley, 2019).

Methane has been rising rapidly in the atmosphere over the past decade, contributing to global climate change (Howarth, 2019) (Hays, McCawley, & Shonkoff, 2017). PAHs (polycyclic aromatic hydrocarbons) are also commonly associated with and adverse health outcomes such as increased cancer risk. PAHs exist in two states in air: freely dissolved in the “gas phase” and bound to particles in the “particulate phase”. Most of the research on health effects of inhaling PAHs has focused only on PAHs measured in the particulate phase. However, a growing body of evidence suggests that PAHs in the gas phase also contribute to the toxicity of inhaled PAH mixtures (Tsai, Shieh, Lee, & Lai, 2002); (Liu, et al., 2007); (Samburova, Zielinska, & Khlystov, 2017)

While carcinogenic potencies are typically higher for individual PAHs with higher molecular weights, lower molecular weight PAHs often present at significantly higher concentrations in the gas phase; this can increase the contribution of gas phase PAHs to the total carcinogenic potency of a PAH mixture (Liu, et al., 2007)

Of particular interest is the release of benzene, toluene, ethylbenzene, and xylene (i.e., BTEX), which are present in low percentages in crude oil and, at sufficient doses, have been associated with adverse human health effects (ATSDR, 2000, 2007a, 2007b, 2010); (Osborn, Vengosh, Warner, & Jackson, 2011). Opportunities for surface spills and leaks of BTEX-containing liquids include lined holding ponds, which are often constructed at well sites for temporary storage of “flowback” or “produced water,” which is the water that comes to the surface with the oil and gas following the hydraulic fracturing procedure (Gross, et al., 2013)



(Fig. 1: General scheme of the hydraulic fracturing process of a well**)**

Impacts from casing leakage, well blowouts, and spills of contaminated fluids are more prevalent but have generally been quickly mitigated (Considine et al, 2012). However, confidentiality requirements dictated by legal investigations, combined with the expedited rate of development and the limited funding for research are substantial impediments to peer-reviewed research into environmental impacts. Furthermore, gas wells are often spaced closely within small areas and could result in cumulative impacts (Engelder, 2009) that develop so slowly that they are hard to measure.

Survey of the literature has identified four plausible risks to water resources associated with shale gas development and hydraulic fracturing. The first risk is contamination of shallow aquifers in areas adjacent to shale gas development through stray gas leaking from improperly constructed or failing gas wells. Over a longer-time scale, the quality of groundwater in aquifers where stray gas contamination has been identified could potentially be impacted by both leaking of saline water and hydraulic fracturing fluids from shale gas wells and by secondary processes induced by the high content of methane in the groundwater (i.e., sulphate reduction).

Thus, evidence of stray gas contamination could be indicative of future water quality degradation, like that observed in some conventional oil and gas fields. The second risk is contamination of water resources in areas of shale gas development and/or waste management by spills, leaks, or disposal of hydraulic fracturing fluids and inadequately treated wastewaters. The third risk is accumulation of metals and radioactive elements on stream, river and lake sediments in wastewater disposal or spill sites, posing an additional long-term impact by slowly releasing toxic elements and radiation to the environment in the impacted areas. The fourth risk is the water footprint through withdrawals of valuable fresh water from dry areas and overexploitation of limited or diminished water resources for shale gas development.

Adverse impact on Environment and humans

(i) Noise Pollution from Fracking

Fracking is associated with increased noise pollution and the consequent risk to human health (Hays, McCawley, & Shonkoff, 2017), (West Virginia Water Research Institute, 2013) and to the fauna species that inhabit the areas where this activity takes place (Todd, et al., 2016); however, noise studies on fracking operations are scarce. From upstream fracking processes, seismic surveys, platform preparation, construction, operation and dismantling, resource supply vehicles and equipment operation, as well as compressors and power plants, all are sources of noise that have great potential to affect the health of workers, and reduce the comfort of wildlife, as has already been shown in migrant birds. The fracking industry produces a complex of transient and chronic noises from different sources, which have yet to be studied.

Thus, as reported by Habicht, Hanson and Faeth in the platforms during fracking the noise reaches more than 100 decibels(dB) (Habicht, Hanson, & Faeth, 2015); moreover, for more than two months noise levels of approximately 60-80dB are maintained. In (Weinhold, 2012), noise measurements in fracking areas in southwestern Pennsylvania are reported. In this study, it was found that instantaneous daytime sound levels ranged from 45.0 to 61.0 dBA, while dosimeters recorded day-night levels of 53.5-69.4 dBA in open spaces and 37.5-50.1 dBA in enclosed spaces.

These results agree with (West Virginia Water Research Institute, 2013), which reviewed an average noise level of 52 dBA with a standard deviation of 10 for several sites on a fracking platform. The noise level decreases as one moves away from the well (Within 90 maximums of 102 dB has been measured, and at 2 km a maximum of 52 dB) (Werner, Vink, Watt, & Jagals).

(ii) Methane

On methane and fracking several works are reported that consider a great contribution in green-house gas production and the impact on global warming, these works mostly appear published in journals that are not in the area of environmental engineering and refer to methane produced by the combustion of gas or oil obtained using the fracking technique; however in (Howarth, 2019) it is estimated that the greenhouse gas footprint of shale gas is greater than that of coal or oil and that between 1.7 to 6% of the methane is vented or leaked to the atmosphere from the wellhead, pipelines and storage facilities.

An increase in methane emissions (up to 2%) has been established in the areas surrounding wells where hydraulic fracturing has been performed in the United States (Osborn, Vengosh, Warner, & Jackson, 2011), this data is not the same for other geographic areas of fracking (Guo, Xu, & Yongqin, 2014), however, the debate has focused on the problem of methane contamination of drinking water associated with shale gas extraction.

Thus, Osborn and collaborators (Osborn, Vengosh, Warner, & Jackson, 2011) reported in 2011 high methane concentrations in water wells near wells with fracking in Pennsylvania, this work received several criticisms and gave rise to new studies that in 2013 concluded that methane is common in water wells in Susquehanna County (Pennsylvania) and its presence correlates better with topography and groundwater geochemistry, and less with shale gas extraction activities, thus concluding the lack of evidence to attribute the presence of methane in water wells to fracking developed in the area (Molofsky, Connor, Wylie, Wagner, & Farhat, 2013). On the other hand, following (Moritz, Helie, Pinti, Larocque, & Barnetche, 2015), it is recommended to plan and maintain a prudent distance between hydraulic fracturing drilling and groundwater sources.

(iii) Risk due to PAH Exposure

Recent research suggests Natural gas extraction (NGE) emits polycyclic aromatic hydrocarbons (PAHs) into air. Studies have concluded that exposure to NGE emissions may pose health risks, and that many important data gaps remain (Shonkoff, Hays, & Finkel, 2014); (Ward, Eykelbosh, & Nicol, 2016). PAHs are pervasive environmental pollutants that are commonly associated with fossil fuel production (Ana, Sridhar, & Emerole, 2012).

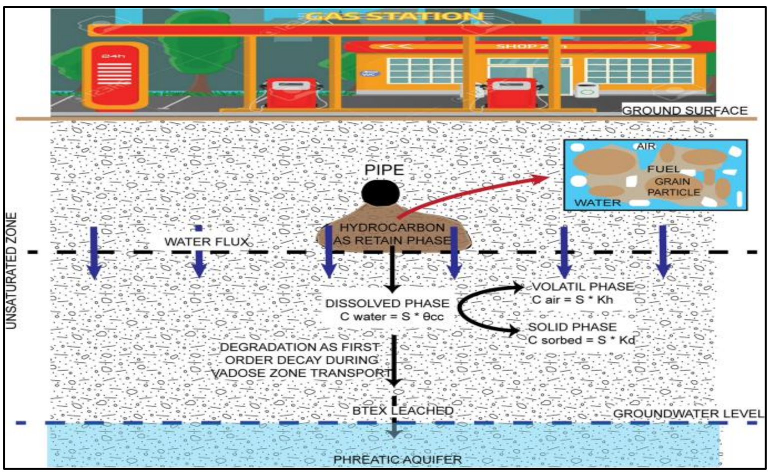
This study used low-density polyethylene passive samplers to measure concentrations of PAHs in air near active and proposed NGE sites. At each site, two concentric rings of air samplers were placed around the active or proposed well pad location. Silicone wristbands were used to assess personal PAH exposures of participants living or working near the sampling sites. Increased understanding of the environmental fate of PAHs emitted from NGE would answer questions about the potential environmental health impacts of these emissions.

PAH in air was significantly higher at active NGE sites than proposed NGE sites. PAH in air quickly dissipated with distance from active NGE sites. PAH was significantly higher in wristbands worn by participants who lived or worked closer to active NGE wells. PAH mixtures in both air and wristbands were more Petro-genic closer to active NGE sites. There was a significant positive correlation between

PAH in wristbands and PAH in air near participants' homes or workplaces. This correlation further affirms the utility of the wristband to assess personal exposure to semi-volatile contaminants, such as PAHs. This work suggests that NGE emits PAHs into air, and that living or working very close to an active NGE well may increase personal PAH exposure.

(iv) BTEX

Benzene, toluene, ethylbenzene, and three isomers of xylene, generally called BTEX, comprise a group of contaminants found in crude oil, coal, and gas deposits. This group is of recent interest because of its reported presence in drinking water wells in fracking areas (Leusch & Bartkow, 2010). Some companies use it as a compound for fluid fractionation, with the risk that fracturing through the hydrological confining layer may create a hydraulic communication between the coal layer and a subway aquifer, contaminating it with BTEX. It should be noted that not all countries require companies to disclose the chemicals that make up fracking fluid; in some countries, such as Australia, the use of BTEX in fracking operations is prohibited (Queensland Government, 2018), (Guo, Xu, & Yongqin, 2014). However, long-term exposure to the components of BTEX affects health widely, causing from ocular and respiratory symptoms to bone marrow and blood disorders (Srebotnjak & Rotkin-Ellman, 2014).



(Fig. 2: Leaching of BTEX into underground water source**)**

Overview of Kumchai EPS (Early Production system) and Drilling sites

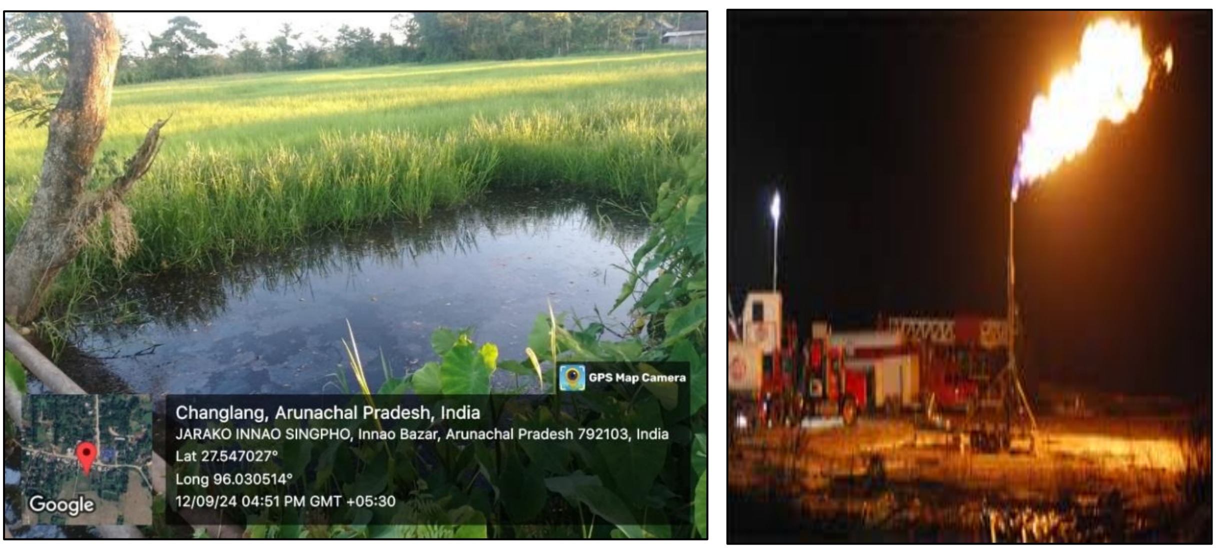
In the context of Arunachal Pradesh, crude oil exploration has gain momentum with the re-grant of petroleum exploration licence (PEL) to Oil India Limited (OIL) after a gap of 15 (fifteen) years on May of 2018, earmarked for Ningroo Block of Changlang and Namsai districts. The agreement between Government of Arunachal Pradesh and Oil India Limited was signed after the last 20 years' Petroleum Exploration Licence (PEL), signed in 1983, expired in 2003. OIL has been exploring crude oil in Arunachal Pradesh since 1963. With the indication of potential deposits, OIL applied for Petroleum Mining Lease (PML) for an area of 551.669 Sq. KMs in 1983. The central government had granted the Ningru PML to OIL for a period of 20 years, effective from 27 November, 1983. OIL has drilled 14 oil wells within Kumchai area of Ningru lease. However, only one well was producing crude oil, and the rest were shut down due to stoppage of oil production. (The Arunachal Times, 06^{th} November, 2018)

At present, 03 (Three) wells are generating crude oil to the tune of 1,20,000 litres per day and 1,30,000 to 1,40,000 standard cubic metre of gas per day (SCMD) of Natural Gas ***after recent success of hydraulic fracking***. Kumchai EPS, is in Ningru Mining Lease Area in Changlang district in the state of Arunachal Pradesh at a latitude of 96^{o}02'55''N and a longitude of 27^{o}33'46''E. The surrounding water bodies around ***Kumchai EPS and the unconventional drilling sites*** (executed and ongoing) are vulnerable to contaminants entering the shallow aquifers due to overflow from effluent pits, faults in casing, and accidental spills during transportation etc. It is a fact, that fracking injects fresh water mixed with chemical additives and proppants (ceramic or sand) under pressure. During the sequential oil or gas recovery process, produced water (PW) emerges as a by-product containing mainly formation water (FW) and a small portion of the fracking fluids as flowback.

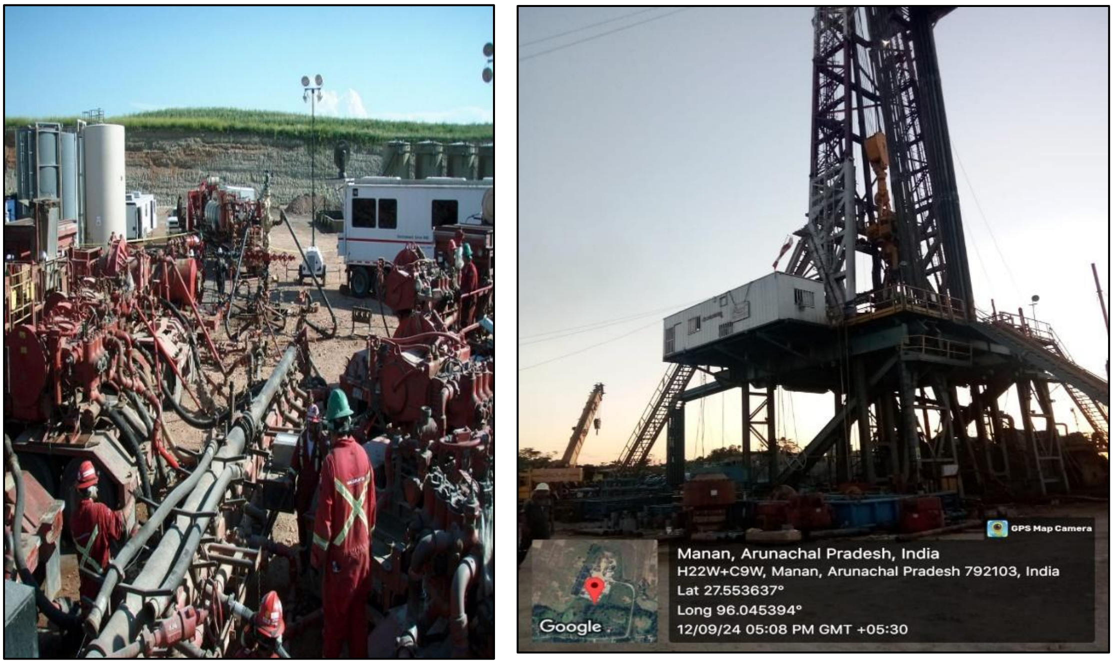
Profile of impact on environment and humans

A photographic view of the crude oil exploration in Kumchai eps and drilling sites and surroundings are compiled here.

(Fig. 3*:* Malodorous effluent pit post drilling filled with chemical debris (volatile and non-volatile): Long term exposure to volatile organic compounds (VOCs) can lead to damage of Kidney, Liver and Central Nervous system in addition to chronic headache and cancer [E.g. benzene exposure is associated with leukemia; (Ningrui Liu et al. 2022,)



(Fig. 4*:* Oily paludal surface water: Contamination of Petroleum hydrocarbon secreted from industrial activity and assembled in lentic water body. Studies have shown strong evidences of risking the health of aquatic flora and fauna [B. Basumatary et al. 2017;



(Fig. 5: Noise Pollution- The WHO recommends indoor noise levels in sleep areas to be below 30 dBA averaged over the 8 hr of night with continuous maximum level limited below 45 dBA. Dosimeter studies recorded day–night levels (Ldn) of 53.5–69.4 dBA outside and 37.5–50.1 dBA inside which are above the permissible limits**)**

(Fig 6*:* A potent contributor to green-house gas production and impact on global warming as 1.7 to 6 % of methane is leaked to the atmosphere. It is recommended to plan and maintain a prudent distance between drilling point and groundwater sources to avoid methane contamination of drinking water**).**

Challenges and prospects

The components of the injected liquids are not in the public domain as they are considered trade secrets. Missing/Inadequacy of data of pollutants before and after the incidents. Different phases of the fracking technique entail latent risks for living organisms. The workers, inhabitants of the areas surrounding the drilling sites and the fauna face potential dangers.

It has been estimated that over the next 20 to 30 years, the density of well sites will increase in the most productive areas of oil and gas recovery (Kennedy, 2007; Pelley, 2003). The current expansion has already introduced oil and gas recovery operations to suburban and urban populations, and concerns have arisen regarding potential adverse health impacts, property damage, and ecological damage. Based on our analysis, we suggest the following recommendations, some of which are specific to the potential for BTEX groundwater contamination from surface spills, and many of which are more general and apply to multiple facets of hydraulic fracturing activities.

A comprehensive chemical risk analysis should be conducted by well operators to provide a formalized method for objectively identifying and evaluating the hazard and expo-sure potential posed by specific chemicals and chemical mixtures that are used in the hydraulic fracturing process (Panko and Hitchcock, 2011). After identifying which chemicals may pose a greater risk, operators may choose to employ alternative chemicals or to implement enhanced safety measures such as additional or increased monitoring for certain chemicals on a regular basis.

Any environmental sampling plan should consider the spatial and temporal variability of chemical concentrations, achieve adequate detection limits, and properly characterize baseline or background levels of chemicals of interest.

CONCLUSIONS

a) Air pollution, gas emissions such as BTEX type compounds and noise pollution are unavoidable facts in drilling and fracking sites and continuous and systematic monitoring actions must be developed throughout the life cycles of the wells. No such studies have been undertaken yet in and around Kumchai EPS and other drilling sites (completed and ongoing).

b) Very few published articles present evidence of risk events materialised by the development of this activity except some accident reports that are little circulated.

c) The studies (short term and long term) will pave way for legal and cabinet amendments about safety of workers and residential public in the vicinity of such industrial zones.

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