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Effects of crude oil pollution in the tropical rainforest biodiversity of Ecuadorian Amazon Region

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Abstract

The interconnectivity among the aquatic ecosystems of Ecuadorian Amazon makes them highly sensitive to broad range of anthropogenic activities like oil pollution. Ecuadorian Amazon biodiversity is in great threats because of the large scale oil pollution by the Chevron-Texaco which systematically dumped 18.5 billion gallons of highly carcinogenic toxic waste into unlined pits, swamps, streams, and rivers into the rainforest from 1964 to 1992. Vast number of ecologically important animals and plants populations is in great threats after this massive oil pollution. The spread of oil and its biological effects is documented immediately. Forest plants, river grasses, algae, and associated invertebrates were badly covered by oil and soon after they are died regularly. The death of Dolphins ,Otter *and* several species of birds has been reported because of oil pollution. The secondary effects of oil pollution are always much greater than the primary effects. So, proper initiatives should be taken in the long run to protect the biological communities of Amazon.

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Introduction

The Amazon River Basin is home to the largest rainforest on planet earth which covers roughly 40% of the South American continent and its territory belonging to eight Latin American countries: Brazil, Peru, Ecuador, Colombia, Venezuela, Guyana and Suriname as well as French Guiana. This big rainforest supports a large and diverse forms of floral and faunal diversity and it's is also well known that every one in ten known species in the world lives here (Maslin *et al.*, 2005).

Amazon rainforest region of Ecuadorian part which contains some of the planet's most bio-diverse ecosystems and are home to thousands of indigenous peoples (Burnham *et al.*, 2004). Below the surface of this fragile jungle also lay reserves of crude oil and natural gas, the ever-growing demand of oil and gas which threatens the fresh water environment and biodiversity that supported by it. In an isolated part of Ecuador, Chevron-Texaco dumped billions of gallons of toxic wastewater into the rainforest from 1964 to 1992 while operating hundreds of oil wells (Rival, 2010). The rainforest dwellers assert that Chevron systematically dumped 18.5 billion gallons of highly carcinogenic toxic waste into unlined pits, swamps, streams, and rivers (Rival, 2010). Today, this waste threatens wildlife biodiversity as well as five indigenous groups with extinction and has created what experts believe could be the worst environmental disaster on the planet other than Chernobyl (Rival, 2010).

Crude oil always has significant negative effects on the aquatic ecosystem on the basis of their composition and concentration. Sometimes, it causes the transformations of the chemical composition of the environment and alteration in its physical properties that lead to the destruction of the nutritional capital of the forest biomass which is so harmful for the human health and as well as for the balance of biological environment.

Effects of oil spill

The ecosystems of Ecuadorian Amazon are sum of the results of all permanent and seasonal waterbodies like lakes, streams, floodplains, marshes, and swamps which are interlinked with the atmospheric, terrestrial and oceanic systems through hydrologic cycle (Da Silva *et al.*, 2005).

There is no clear relationship between the amount of oil in the aquatic environment and the likely impact on Biodiversity (Davidson, 2009). A smaller spill at the wrong time/wrong season and in a sensitive environment may prove much more harmful than a larger spill at another time of the year in another or even the same environment. Even small spills can have very large effects (Houghton, 2012). Thus, one should not merely compare graphics; the size of an oil spill is certainly not the only factor of importance in terms of what environmental damage can be caused by the oil. Oil is toxic to almost all organisms. The toxic effect depends on the composition and concentration of the oil, and the sensitivity of the species affected (Mosbech, 2012). Oil spill have both quantitative and qualitative costs. Quantitative costs limited to clean up exercises, penalties, on the other hand qualitatively, it causes the disappearance of pristine wildlife habitat, lethal effects on health (Fig. 1).

Effects on microbial populations

Prokaryotes dominate many Amazonian environments and play major roles in food chains, biogeochemical cycles and the mineralization of pollutants such as oil spills. Further prokaryotes can have beneficial or detrimental effects on other groups of organisms including vegetation, invertebrates and fish. The changes of microbial communities in aquatic environments must thus be considered with great care, since general changes in important groups of microorganisms might be followed by changes in the higher populations. To my knowledge, still no true research is carried out on how oils spills affect microbial populations in aquatic environment of the Ecuadorian Amazon. It is therefore recommended that an integrated study should performed assessing

both the oil degradation ability on selected areas in Ecuadorian Amazon, as well as assessing the diversity of the microbial populations in the particular environmental sample. However, by review some literatures we can easily assuemed the oil spill effects on microbial population. In a study describing the microbial ecology changes following the 1997-tanker accident in the Japan Sea the microbial populations have been analyzed using PCR-denaturing gradient gel electrophoresis (DGGE). In this study no control plot analysis could be used to compare the oily samples, but the same general groups of bacteria (alfa-Proteobacteria) were found to dominate the contaminated water samples (Kasai *et al.*, 2001). The group further found that the bacteria present in the oil paste samples belonged to types related to hydrocarbon degraders, exemplified by strains related to *Sphingomonas subarctica* (Kasai *et al.*, 2001).

Effects on vegetation

Oil spill always have significant short and long-term effects on aquatic ecosystems. Chemical toxicity of the oil affects the plant water relationship, affect metabolism, become toxic to cell, hamper the photosynthesis of aquatic plants, and interfere with oxygen intake from atmosphere and soils. How visible oil affects the aquatic environment shown in the fig.1. During flood, spilled oil enter into the center of the forest floor, and plants leaves and stem become covered by oil which blocked the stomata, reduced oxygen diffusion to the roots, result will hamper the plant growth. Oil already mixed with soil has reduced oxygen resulting to anaerobic condition that in effect increases plant stress. Laboratory result showed that Plants with blocked leaves are more severely affected as compared to plants in contaminated soils (Ko and Day, 2004). It is reported that the floating plant species is spreading thin layer of oil in the whole river. This floating object with oil coating is helping in oil spread too. By visual observation it's noted that most of the plants of the Cuyabeno Wildlife Reserve are covered by oil including a vegetation dominated by Palms (*Mauritia flexuosa*). While some apparent acute effects of oil exposure (i.e., loss of leaves from some young aquatic trees at the low tide margin) were observed along two creeks, resource experts from the Department of Forest also noted that new growth had already begun to appear on the plants. Though in naked eyes, effect of oil spill on the Cuyabeno vegetation is not strongly reported but it has long term effect on it without any doubt. In addition, clean-up process of the oil causes physical disturbance and compaction of the vegetation and soil (Pezeshki *et al.*, 2000).

Effects wildlife

Oil spill have significant short and long-term negative effects on wildlife population of all trophic levels living in and around the aquatic ecosystems. Ecuadorian Amazon is the habitat of most famous wildlife species which supports 1,600 bird species (15% of the world's known bird species) in the continental area and 38 more endemic in the Galapagos. In addition to over 16,000 species of plants, the country has 106 endemic reptiles, 138 endemic amphibians, and 6,000 species of butterfly. But vast number of wildlife species in the Ecuadorian Amazon region are in threatened condition according to IUCN (Fig. 2). Notable wildlife species in Ecuadorian Amazons are the lowland tapirs, two species of deer, all Amazon cats, including jaguars and pumas, capybaras, two species of dolphins (*Inia geoffrensis* and *Inia geoffrensis humboldtiana*), two species of otter- giant otter (*Pteronura brasiliensis*) and neotropical otter (*Lutra longicaudis*), etc. Monkeys are represented by 10 species, while rodents and bats are represented by dozens of species (Araya and Peters, 2001). From the very beginning of oil pollution the death of several wildlife species of Ecuadorian Amazon has been reported in different times (IUCN, 2015). Basically, Oil harms water birds and aquatic mammals in two major ways:

Physical contact

when fur or feathers come into contact with oil;

Toxic contamination

some species are susceptible to the toxic effects of

inhaled or ingested oil. Oil vapors can cause damage to an animal's central nervous system, liver, and lungs. Animals are also at risk from ingesting oil, which can reduce the animal's ability to eat or digest its food by damaging cells in the intestinal tract. Some studies showed that there can also be long-term reproductive problems in animals that have been exposed to oil.

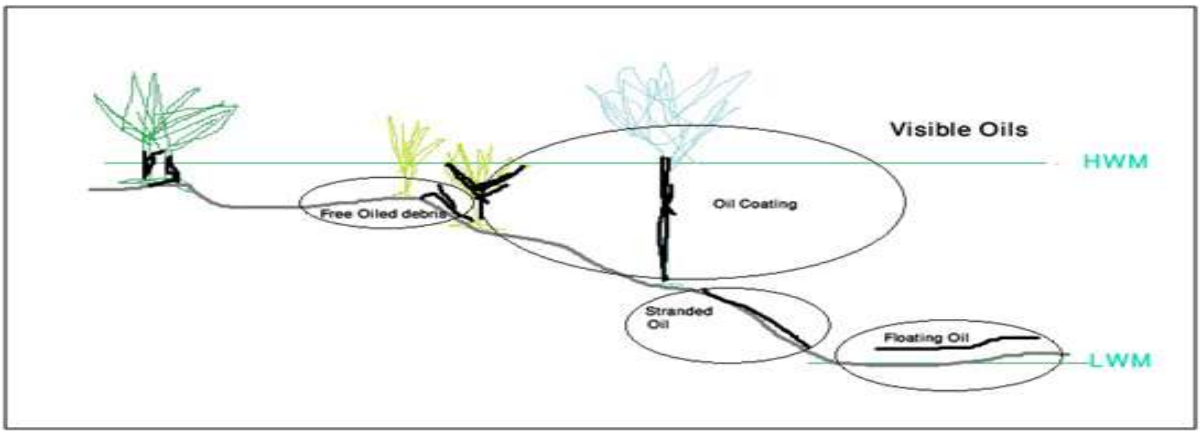

Fig. 1. Visible oils in the environment (HWM – high water-mark, LWM – low water-mark).

As summarized by the Australian Maritime Safety Authority (AMSA) (Gilbert, 2001)., important factors related to the impact of an oil spill on wildlife are:

the spread of the oil slick,
the type of oil spilled, its movement and weathering characteristics
the location of the spill,
the area of estuary, sea and foreshore impacted by oil,
the sensitivity of the regional environment, e.g. proximity to bird breeding colony,
the number of different habitats impacted, such as rock shore, beach, mangrove, wetland,
the timing of the incident (during seasonal breeding, bird migration),
the nature, toxicity and persistence of the oil; and
the variety of species at the spill location.

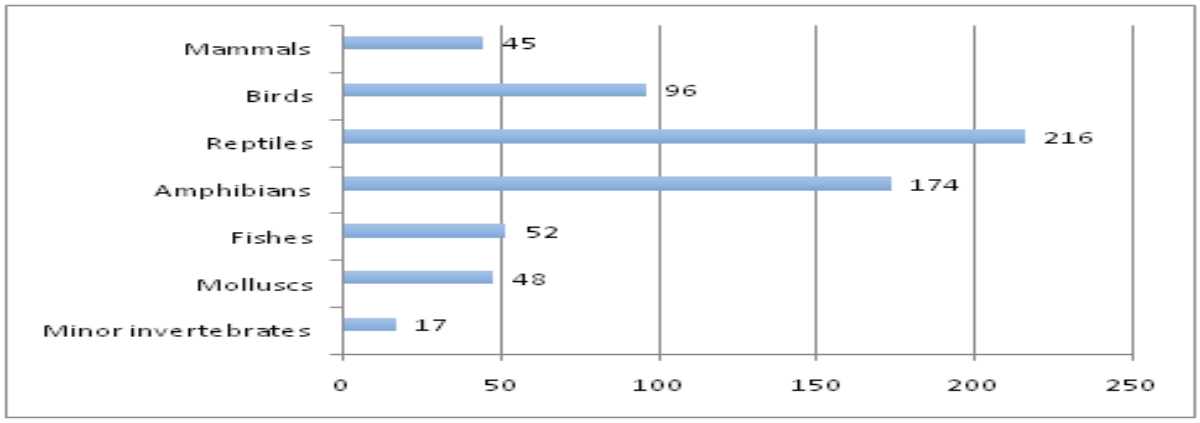

Fig. 2. IUCN Red list of threatened species in Ecuador 2015.

Since most oils float, the creatures most affected by oil are animals like otters and aquatic birds that are found on the water surface or on river bank if the oil comes river slope. During most oil spills, water birds are harmed and killed in greater numbers than other kinds of creatures. Otters can easily be harmed by oil, since their ability to stay warm depends on their fur remaining clean. If oil remains on two sides of river for a while, other creatures, such as snails, clams, and terrestrial animals may suffer.

Impacts of oil spill on fish

Ecuadorian Amazon fresh water ecosystems considered as the habitat of almost 350 fish species. Oil can affect fish in many ways. Fish readily take up oil components into their tissues after exposure to oil in water, food or sediment. Oil may cause a number of physiological and histopathological effects depending on the concentration and composition of the oil.

In laboratory studies several fish species have been exposed to the water-soluble fraction (WSF) of different crude oils. The WSF of crude oils consists mainly of aromatics and are dominated by benzene, toluene and xylenes (Serigstad, 1992). The toxicity to fish appears to be functionally related to the total aromatic hydrocarbon concentration in the WSF (Rice, 1985). As a broad generalization, lethal effects (LC50) among adult fish are found in the range 1 – 10 mg/kg of water soluble aromatics and sub lethal effects in the range 0.1 - 1 mg/kg. Fish eggs and larvae are generally more sensitive than adult fish. Lethal effects (LC50) of water-soluble aromatic hydrocarbons on larvae have been estimated to be in the range 0.1 - 1 mg/kg (Rice 1985). Carls *et al.* and Heintz *et al.* (both 1999) found a higher sensitivity of herring and pink salmon embryos during long-term exposure to weathered Exxon Valdez crude oil. Lowest observed effective concentrations (LOECs) were about 1 µg/kg (ppb) total PAH from very weathered oil (Heintz *et al.*,1999). Total PAH from less weathered oil was less toxic indicating that toxicity in the very weathered oil was primarily associated with the larger PAHs.

Conclusion

Oil spill incidents in the Ecuadorian Amazon are considered as a severe oil spill accident from ecological point of view. Already the death of several globally important wildlife species has been reported, another vast number of species severely affected by oil coating. Most of the plant species leaves and stem has been covered by oil. After any disaster it's seems that the effects are not so severe but we have to take in account that for this types of incident secondary effects are much more dangerous than the primary effects. For developing economy country like Ecuador the secondary effects of oil spill could be devastating because they do not have sufficient technology and skilled manpower for proper clean-up process, besides this they also have bureaucratic complexity for taking proper and instant initiatives which always delay the clean-up process. So, for protecting this ecologically important world most biodiversity rich site government should take proper steps to minimize this types of incident. For this, government should build proper navigation channel that will not affect the important ecosystem of Amazon and have to ban the passage of vessels through the rivers and have to adopt modern technology and should build up trained manpower to minimize this types of accident in near future.

Competing Interests

Authors have declared that no competing interests exist.

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