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Oil extraction in the Amazon basin and exposure to metals in indigenous populations

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A B S T R A C T

Most oil extraction areas in the Peruvian Amazon are within indigenous territories. Poor environmental practices have exposed the indigenous population to metals. We conducted a survey in two indigenous Kukama communities to assess body burdens of metals after the occurrence of two major oil spills in 2014. Urine levels above those recommended by the Peruvian Ministry of Health were observed in 50% and 17% of the study population for mercury and cadmium, respectively.

1. Background

The Western Amazon contains large reserves of oil and gas (Finer et al., 2008). In the northern Peruvian Amazon, oil concessions known as Blocks 1AB and 8 were drawn at the late 1960 over the whole of the Corrientes, Pastaza and Tigre river basins (Loreto, Peru), tributary rivers of the Marañon river (Fig. 1). More than 45,000 Achuar, Urarina, Quechua, Kichwa and Kukama-kukamilla indigenous people live in these river basins.

Crude oil, produced waters and drilling muds can contain a number of potentially toxic agents, including heavy metals, such as lead, cadmium, arsenic and mercury amongst others (E&P Forum/UNEP, 1997; Fakhru'l-Razi et al., 2009; Lienemann et al., 2007; Neff, 2002; Wilhelm, 1999). Poor environmental practices by the oil industry, such as the dumping of around 1 million barrels/day of produced water on soils and rivers in the study area, and recurrent oil spills have contaminated the Corrientes, Pastaza, and Tigre river basins, all tributary rivers of the Marañon river (Fig. 1) and exposed the indigenous population to metals among other contaminants (Orta-Martínez et al., 2018; Orta Martínez et al., 2007). Since the 80's different Peruvian state agencies reported high levels of hydrocarbons and heavy metals related to oil extraction activities in environmental samples, and high levels of cadmium and lead in blood among the local population of this area (Orta Martínez et al., 2007). Exposure to metals is associated with several negative health outcomes, including neurological, respiratory, renal and cardiovascular effects, and increased risk of cancer (Järup, 2003; Vrijheid et al., 2016).

The 30th of June 2014, an oil spill of the Northern Peruvian pipeline (ONP, by its Spanish acronym) released 2358 barrels of crude oil to the environment, coating over 87,000 m^2 of the territory of the indigenous community of Cuninico (Expediente Resolución Directoral No. 844-2015-OEFA/DFSAI Expediente No. 1306-2014-OEFA/DFSAI/PAS. 2015; UTM WGS84 N9474535, E467992). A few months later, the 16th of November 2014, an oil spill in the same region released approximately 7800 barrels of crude affecting the territory of the indigenous community of San Pedro (Goldenberg, 2014). Approximately one year

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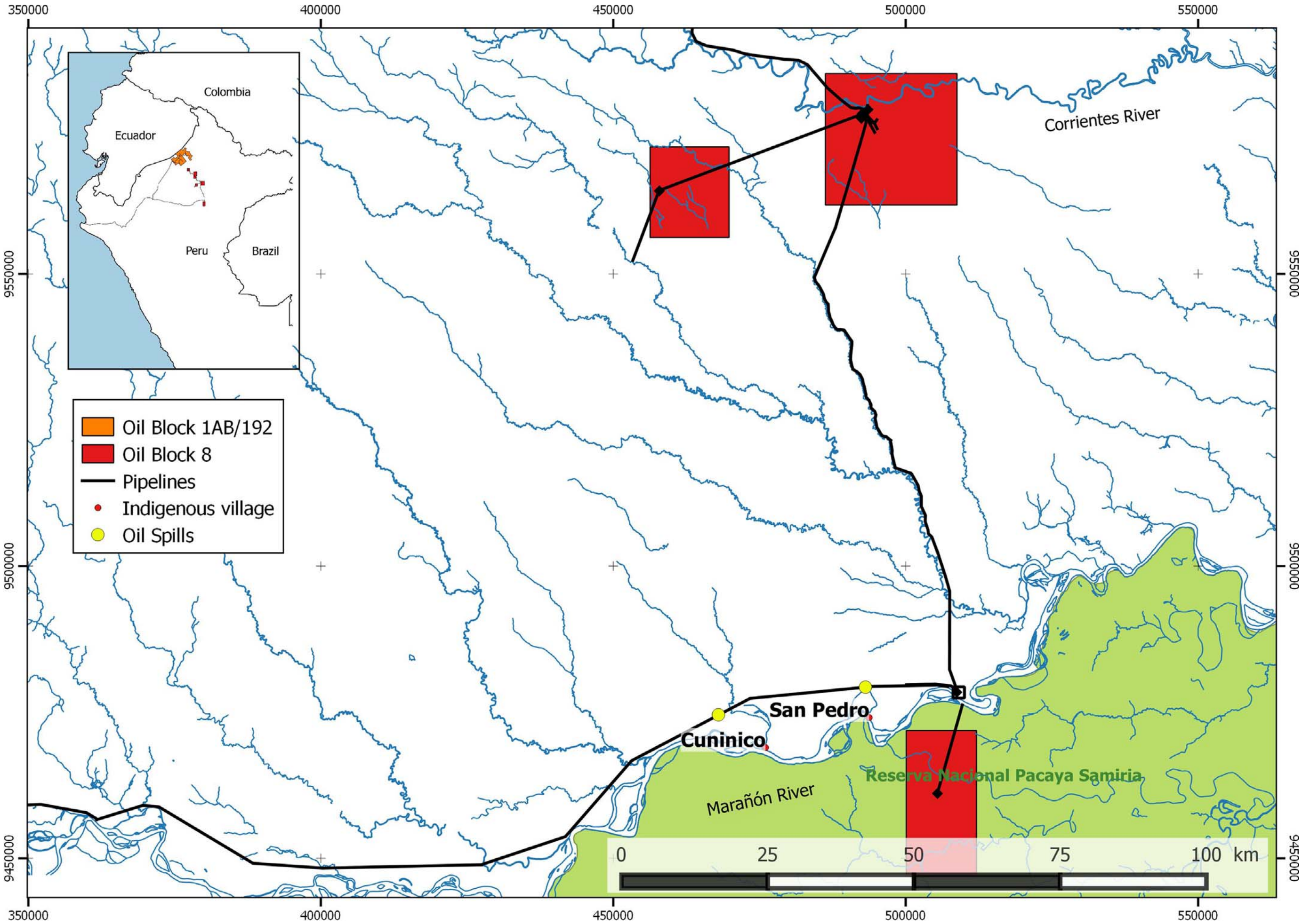

Fig. 1. Map of the study area.

after these major spills, we surveyed these two Kukama communities to assess blood and urine levels of metals often found in crude oil.

2. Methods

In January 2016, CENSOPAS-INS, the center for occupational and environmental health of the Peruvian National Institute of Health, conducted an assessment of metal concentrations in the inhabitants of Cuninico and San Pedro. Participation was offered to all inhabitants that had been living in these communities during at least the previous six months. The study protocol was reviewed and accepted by the Ethics Committee (Comité Institucional de Ética en Investigación) of the National Institute of Health, Peru. All participating subjects provided written informed consent.

Demographic data and information on involvement in oil clean-up activities were collected through structured questionnaires. Venous blood and urine were collected, and preserved following standardized CENSOPAS-INS procedures (Carreón Valencia et al., 1995; Centers for Disease Control and Prevention, 2016). Concentration of metals were determined using protocols validated by CENSOPAS-INS. Specifically, atomic absorption spectrophotometry (AAS) in graphite chamber was used for lead in blood (Instituto Nacional de Seguridad e Higiene en el Trabajo. Ministerio de de trabajo y asuntos sociales España, n.d.) and for cadmium in urine (adapted version of (NIOSH, 1994)). Flow injection –hydride generation AAS was used for arsenic in urine (adapted version of (Intersociety Committee and Morris Katz, 1989)) and cold vapour AAS was used for mercury in urine (Instituto Nacional de Seguridad e Higiene en el Trabajo. Ministerio de de trabajo y asuntos sociales España, 2001). Creatinine in urine was measured by mass spectrophotometry using kinetic Jaffe method (Wiener Lab. Ref 1260360).

Method limits of detection (LOD) applied were 2 μg/dL for lead, 2.5 μg/L for arsenic and mercury, and 0.5 μg/L for cadmium. We replaced metal values below the LOD by LOD/2. To account for urinary dilution, we corrected levels of arsenic, cadmium, and mercury with creatinine concentrations, when creatinine values where within acceptable ranges for human biomonitoring (> 0.3- < 3.0 g/L) (American Conference of Governmental Industrial Hygienists (ACGIH), 2017). Samples with creatinine values outside this range were not included in the analysis. For all metals under study, we used as reference values those established by the Peruvian Ministry of Health (MINSA): < 10 μg lead/dL blood, 20 μg arsenic/g creatinine, 2 μg cadmium/g creatinine and 5 μg mercury/g creatinine.

We conducted descriptive analyses of the study population characteristics and levels of metals. We examined the distribution levels of metals among the study population. As levels of metals among the study participants did not follow a normal distribution, we compared median levels of metals according to demographic characteristics using non-parametric tests (i.e. Wilcoxon rank-sum test for variables with two categories and Kruskal-Wallis test for variables with more than two categories). Correlation between levels of metals was tested using Spearman's rank correlation coefficient. Levels of metals were log transformed to approach normal distribution. Association between self-reported involvement in clean-up activities and levels of metals (log transformed) was studied among the overall population using linear regression models adjusted for age and sex.