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EXTENDED ABSTRACT

Hybrid Soil Washing Process with Ozonation in a Sequencing Batch Reactor to Remediate Arsenic-Contaminated Soil and Petroleum Compounds

Sogand Vaziri, Roya Mafigholami *, Sanaz Khoramipoor

Department of Environmental Science and Engineering, Islamic Azad University West Tehran Branch, Tehran, Iran

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Soil washing process, Ozonation process, Suspended biological reactor, Soil pollution, Arsenic.

1. Introduction

Today, soil pollution is one the most concerning issues relating to environment (Mishra et al, 2019). Soil pollution leads to transfer of organic and inorganic contaminants to plants and animals and finally to human food chain which causes detrimental effects on human health (Wu et al, 2017). One of the metals that have been used by humans is Arsenic. This metal and its compounds are used in medical and dentistry purposes, electrical industry, pesticide and herbicide industry, alloy manufacturing, etc. Arsenic is one of 10 dangerous elements which is considered a threat to public health by World Health Organization (WHO; Beykpour and Arghavan, 2020)

To eliminate and mineralize organic contaminants, multiple processes have been utilized. For example, different oxidizers including Chloride or hydrogen peroxide degrade contaminants throughoxidating agents like hydroxyl and superoxide radicals (Xiao et al, 2015). Moreover, soil washing process was observed to eliminate Cadmium and lead from polluted soil (Feng et al., 2020). Furthermore, biological processes are one of the methods to remediate organic and inorganic pollutants. In this regard, sequencing batch reactor (SBR) is used to treat municipal and industrial wastewater. Due to some special features, this system has gained increasing attention in Europe, China, USA (Jafarinejad, 2017). The purpose of this study is to determine the efficiency of soil washing/ ozonation/ SBR as a hybrid process to remediate polluted soil.

2. Methodology

In this study, sampling was conducted in the vicinity of South Tehran refinery and petrochemical factories. Composite samples were mixed and analyzed. In this section, heavy metals concentration and total petroleum hydrocarbon (TPH; as COD index) was determined. To determine Arsenic concentration, Inductively Coupled Plasma (ICP) Spectroscopy was used.

2.1. Experimental tests

To prepare the soil washing process, 50 g of polluted soil were mixed with 500 ml of surfactant with variant concentrations. Then the solutions were stirred at 300 rpm for 8 h. After that, solutions were kept still for 72 h to settle. Subsequently, supernatant was extracted for COD and Arsenic analysis and was transferred for

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* Corresponding Author
E-mail addresses: s.vaziri1140@gmail.com (Sogand Vaziri), r.mafigholami@wtiau.ac.ir (Roya Mafigholami), khorami.sanaz@wtiau.ac.ir (Sanaz Khoramipoor).

ozonation process. In ozonation process, Ozone gas was injected by a silicone hose to the solution. Different concentration of Ozone gas were applied with a specified period according to RSM prior to analyzing COD and Arsenic. Finally, solutions were transferred for SBR process. A reactor with 20 L capacity was used. Aeration and mixing was applied by an aerator at the bottom of the reactor.

2.2. Optimization experiments

To optimize the variables in three processes, response surface methodology (RSM) was used with central composite design (CCD). pH, washing time and surfactant concentration was optimized in soil washing process. In ozonation process, variables are pH, ozone concentration and reaction time and in SBR process, pH, Sludge retention time (SRT) and hydraulic retention time (HRT) were optimized. Table 1 illustrates 5 levels of variables in three processes in CCD model. Finally, COD and Arsenic concentration were determined as response in this model.

Table 1. Variables in three process and 5 levels in CCD model

		$-\alpha$	Low	Middle	High	$+\alpha$
Soil washing	pH	2	4	6	8	10
	Washing time (min)	20	40	60	80	100
	Surfactant concentration (mg/l)	10	20	30	40	50
Ozonation	pH	2	4	6	8	10
	Ozone concentration (mg/l.min)	1	2	3	4	5
	Reaction time (min)	10	20	30	40	50
SBR	HRT (hr)	6	12	18	24	30
	SRT (day)	2	4	6	8	10
	Oxygen concentration (mg/l)	1	2	3	4	5

3. Results and discussion

In optimization in variables in soil washing, washing time was the most effective variable tin eliminating COD and Arsenic. In other words, the optimum washing time was 100min. The second effective variable was surfactant concentration which was optimized at 47.8mg/l. In ozonation process, Ozone concentration was the most effective variable in removing COD which was optimized at 5mg/l. min. in this process, Arsenic concentration remained constant. In the SBR process, the most effective variable was HRT which was optimized at 30 h.

Finally, four experiments with offered optimized variables were conducted to reach the optimum COD and Arsenic degradation in all process. According to the results of this study, the optimum Arsenic and COD removal in soil washing process is %84.3±1.7 and %82.3±1.2, respectively. Ozonation process were optimized to remove %91.0±0.8 of COD and finally in SRT process, the COD and Arsenic removal were observed to be %82±2.1 and %84.6±2.9, respectively.

4. Conclusion

Hybrid process of soil washing/ ozonation/ SBR were optimized in this study to remove COD and Arsenic of polluted soil. According to the results of this study, this hybrid process is able to mineralize and degrade contaminants like leachate which is riched with COD and Arsenic. According to the results, soil washing process was able to remove %84.3±1.7 and %82.3±.12 of COD and Arsenic, respectively. In the next process, ozonation, could remove %91.0±0.8 of COD, but had no effect in Arsenic removal. Finally, SBR process was able to remove %84.6±2.9 and %82±2.1 of COD and Arsenic, respectively. The final concentration of COD and Arsenic were reduced to 297.4 and 5.22 mg/l, respectively.

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