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Environmental Management of Oil Pipelines Risks in the Wetland Areas by Delphi and MCDM Techniques: Case of Shadegan International Wetland, Iran

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ABSTRACT: The aim of this study is to assess the risk factors of pipelines and prioritize their severity in order to prevent their effects in Shadegan International wetland, Iran. Due to the participatory nature of the managerial affairs, the study employs an integrated approach that combines Analytic Hierarchy Process (AHP) and Delphi Method. Also, Likret Scale has been applied to quantify the qualitative (verbal) data, thus reducing the uncertainty of oil pipelines' risk evaluation. In order to evaluate potential risk factors, Failure Mode Effects Analysis (FMEA) method has been applied. According to the study results, in terms of the likelihood of environmental impacts on the main considered criteria of natural and man-made environments, the former's effect is a priority risk, weighing 0.670 and primarily important. On the other hand, environmental hazards caused by oil pipes of water quality in Shadegan wetland has been ranked first, with a relative weight of 0.389 to contain the highest level of risk. The risk degree for diversity and density of benthos is 12.6 and 6.3for fish, both higher than other parameters of water systems in Shadegan wetland. Considering the recognized factors that lead to probable risks of pipelines along with their most notable outcomes, the paper suggests environmental management plans on how to control and reduce the potential impacts, with an emphasis on elimination of the most likely causes.

Keywords: AHP, FMEA, Shadegan wetland, Environmental ecosystems, Delphi Method.

INTRODUCTION

Environmental risk assessment is considered a systematic approach to decision-making (US Department of Transport, 2011; Muhlbauer, 2004), which can be considered an effective process for continuous improvement of environmental conditions, capable of reducing the risks to an acceptable level (Monavari, 2007). It is a process to qualitatively analyze not only potential risk factors but also actual to potential risks in the project, not to mention sensitivity or vulnerability of the environment. Additionally this assessment tool analyzes various aspects of risk, with full recognition of the environment, which determines the sensitivity of the affected area along with the environmental value in the field of risk analysis (Hanson, 2008).

Assessing the potential risk of a project and its likely impacts on environment parameters, as establishing an environmental management system is the primary objective of environmental risk (Malmasi et al., 2010), which can be used to design, construct,

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operate, and maintain development projects, with the least risk and highest safety and is of strong interest to managers and planners (Crowl and Jo, 2008).

It is well accepted that transporting crude oil via pipeline is more efficient, capable of moving large amount of fluids in a certain amount of time. Thus, Pipeline is known to be the safest way to transport oil and gas worldwide with an average failure rate of 0.6 per 1000 km years for onshore pipeline. However, the pipelines route from the oilfield and import sites to the consumption sites raises many environmental issues.

This paper examines the environmental risk of oil pipelines in Shadegan wetland and its surrounding area in Khuzestan Province. Based on all the activities envisaged in these pipelines, there are significant risks, threatening local residents, staff, and constituent elements of ecosystems which are potentially performing an activity. In addition, pipeline constructions in the vicinity of the wetland area, from which they kept extracting the fluid, led to some contaminations that may affect the surrounding creeks as they are the most important ecosystems of biodiversity.

Pollution control issues have caused a great concern in Shadegan wetland, an area sensitive to both the environment and the local people. It should be realized that the best pollution control measures should be incorporated in the final design and operating procedures so that the wetland's natural resources can be protected (Sardar,et al., 2009; Karbassi et al., 2008). The environmental impact analysis indicates that the offshore pipeline can be constructed in such a way not to cause any unacceptable impact on the area's biodiversity and conservation interests.

MATERIAL AND METHODS

The wetland in Shadegan is one of Iran's international wetlands listed in Ramsar's Convention, held in 1971 (Montazer-Hojat et al., 2015). Located at the end of the Jarahi River in southwest Iran, Khuzestan Province (Scott, 2007) (Fig. 1), with an area of 400000 hectares, it is the 34th largest wetland in the world and the largest one in Middle East.

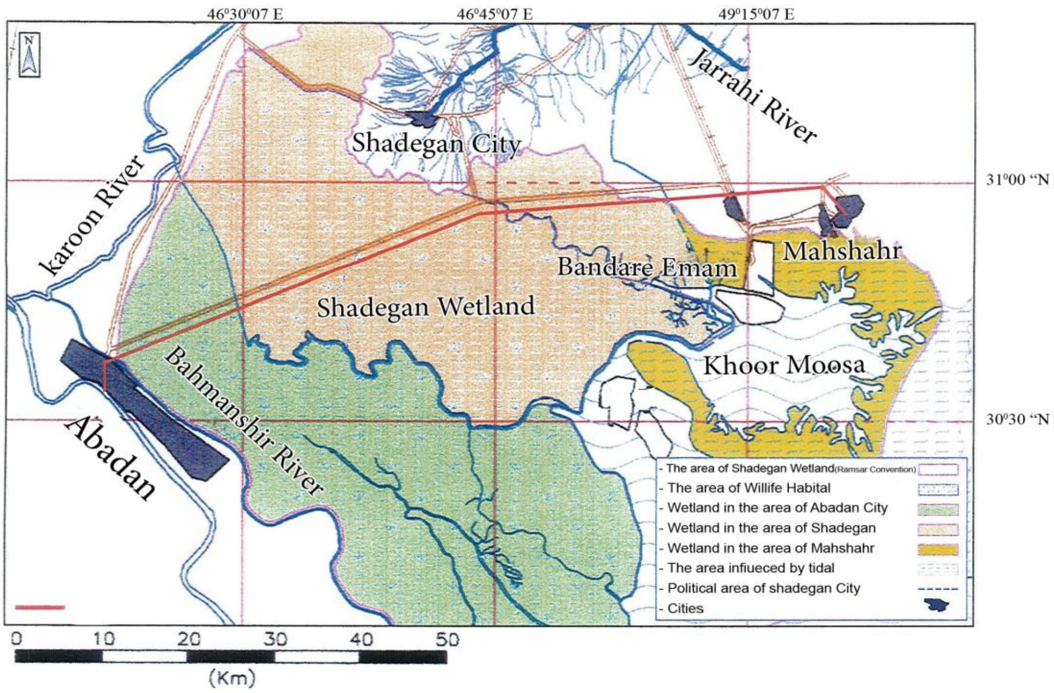

Fig. 1. Location of pipelines in the Shadegan wetland

Shadegan wetland makes it possible to foster sustainable development. Notwithstanding, unsustainable activities, particularly those involving chemical industries, pollution, mismanagement of water resources, and other improper activities have imperiled it (Kaffashi et al., 2011; Monavari, 2009). There are two crude oil pipelines, 53 km long, which goes through Shadegan wetland from Bandar Mahshar, Khouzestan Province, in south-west of Iran (Davami et al., 2014).

To assess the environmental risks of oil pipelines, the first step would be identifying the most important environmental aspects and impacts (Kandiyoti, 2012). The study firstly examined the environment situation in the study area, then to examine fine construction and operation phases of the activities. In order to both check the water pollution of Shadegan wetland along with the creeks, radiating from it, and determine the level of biodiversity for aquatic species, it analyzed physical and chemical parameters as well as the biological draft.

Since there are two risks, namely probability of predicted risk and severity of the potential consequences are an unwanted event (Brody, et al., 2006). Due to the participatory nature of the managerial affairs, an integrated approach, combining Analytic Hierarchy Process (AHP) and Delphi Method (Culley, 2011) was applied.

Three Delphi panels were composed of environmental experts, residing in the province of the study area, in the context of risk assessment. To get accurate results, the study methodology was described to them (Geist, 2010).

In the first round, 25 questionnaires, containing environmental criteria were distributed among 40 experts as members of the panel. Out of the total 25 questionnaires, eight were not assessed due to lack of response or incomplete answers. Totally 23 criteria were included in the questionnaire. At the end of the first round, panel members added three new criteria to the questionnaire.

In the second round, 26 criteria already existed in the questionnaire and 8 more were derived from the panel team's new ideas which were given to 18 experts who participated in the last round. In this round, five questionnaires were excluded as a result of incomplete answers or failure to receive responses, leaving 12 questionnaires to be evaluated. Results of the average scores, determined by panel members as well as the considered person in the previous round of surveys, were placed at the disposal of a group.

In the next round, 21 criteria were given to the team who attended the last round. In this round, results of the average scores, determined by experts as well as the considered person in the last round of poll, were placed at the disposal of each of the members to be compared and finalized. The Kendall's coefficient of concordance was computed as 0.76 (which is higher than 0.5), which considering that the number of panel members were more than 10 people, made it significant. Therewith, a consensus was created among the panel members and the Delphi was stopped at the third round.

AHP method is one of the multi-criteria decision making techniques (Kheirkhah Ghehi et al., 2013; Brito, et al., 2009; and Mirghafouri and Kousha, 2015). In this way, weighting criteria, sub-criteria, and priority options are performed, using the technique of "special vector" (Dey, 2010). Also, in this way, the use of the software Expert Choice is set by the relative weights of the criteria and sub-criteria, determining the final weight options.

Classification for the severity of the risks of the pipelines was in accordance with the classification of the severity of the effects of the technique on Failure Modes and Effects Analysis (FMEA) (Chiozza and Ponzetti, 2009; wangpoon et al., 2009; Segismundo, et al., 2008; Kumar, 2005).

Results and Discussion

Due to the studied pipelines, the most important environmental hazards included fuel explosion, oil spills from pipes, leaking fuel when transporting and unloading, explosion at other facilities that are either available already or under construction, discharge wastes, dredging, and particle layer. Potential environmental risks included natural environmental risks as well as risks for human environment.

The most important surface water resources in the study area were some creeks including Shadegan wetland, Khoor Moosa, and Khoor Samaili, along with Jarrahi River.

As a result of dredging and earthworks operations, due to discharge of silt and sludge and dredging of aquatic ecosystem, parameters such as TDS, TSS, sodium, calcium, phosphate, and other minerals undergo some changes (Alencar et al., 2010). Also, consumption of oxygen by decaying and decomposing organic materials created anaerobic conditions, reducing water quality in the affected area, thus increasing the COD and BOD of water. The study area is located in Khalaf-abad-Shadegan plain with the water depth of the area being 60 cm in average (Ramsar Convention Secretariat, 2007). Any oil spills from pipes, facilities, tanks, and special equipment on the ground may contaminate the groundwater in the study area.

Oil spills from the pipelines, in an aquatic ecosystem, caused potential adverse impacts on biological environment (Narjes, 2013; ENSR Corporation, 2007). According to studies, the mud zone in the western part of Shadegan wetland is considered the location for disposal of dredged particle layer. It includes lands that are in fashion, being under water and an appropriate habitat for some fish like Mudskippers. It can be seen during low tide on the muddy sediments in creeks. Also, it is a perfect station for fishing vessels to stop or traffic. The highest frequency of benthic organisms in these habitats belong to the family of Amphipods, Polychaetes, Copepods, and Coupe (Hosseini Alhashemi et al., 2012).

Petroleum products, available in dredging sludge (Li et al., 2015) and discharged into receiving waters, affect the fish in the waters of the region. In addition, higher sediment loads and suspended solids in the creeks along with the impact of dredging on vessels' rotation that lead to the docks, ends up with the destruction of the habitat for aquatic invertebrates, population decline in benthos, and impaired gill and feed of the fish.

Most likely, disposal of earthwork materials in creek water is followed by negative outcomes, usually due to deposited materials or solid phase, which could affect both organisms (Kim et al., 2011) and benthic, by coating the substrate and habitat for them. This results in the integration of bio and toxicity of the liquid phases and suspended (Liu, 2014). Also, heavy metals, a component of petroleum and its derivatives, are deposited on the substrate of creeks and wetland (Muralidharan et al., 2004), ending up with the destruction of benthic communities.

Other pipeline activities that contribute to the risk included recoverable oil reserves of land for the establishment of the pipes. The depth of the extraction area was 2 meters, being a habitat for some fish in the region. Following pipeline implementation, this habitat would get destroyed and the dependent benthic communities would be lost.

Some plants like Salsola sp. and some weed species grow in the mud at the aquatic area and its surroundings (Kaffashi et al., 2011). On the margins, however, this changes to mangrove trees, planted by hand. Oil products available on dredging sludge, discharged into receiving waters, affect the fish in territorial waters, whereby suspended solids including grease, oil, and petroleum products, create a thin layer on the surface of the water, leading to the consumption of dissolved oxygen in the water. They can stop the process of photosynthesis and oxygen absorption in the water (Colavito, 2002). For drinking water, the pollution caused by oil is toxic to phytoplankton. Oil makes an impermeable layer that prevents gas exchange, reducing not only the depth of light penetration but also photosynthesis. Given that biological organisms depend on phytoplankton, other living creatures are affected, too (Ramsar Convention.2010; Jica, et al., 2003).

Shadegan wetland is the only zone under the protection of the Department of Environmental, Khuzestan Province, in the study area, through which the pipelines pass (Assessors of the environment Co., 2007). Hence, the risks and environmental impacts from construction and operation of pipeline activities in this area are very probable.

Considering various contaminants, water, and wastes which are released during oil pipeline operations, it is obviously right to ignore them and their proper disposal take place for the following reasons:

1) Accidents are often due to unsafe conditions or unsafe acts. The former usually draws from improper designing the procedure or equipment, not to mention risky work conditions while the latter is typically a consequence of human factors and errors. Therefore, accidents due to unsafe conditions damage the machines, equipment, products, manufacture processes, or work area, whereas the ones arising from unsafe acts cause irrecoverable damages to human beings (National Iranian Oil Engineering and Construction Co. 2017).

2) Contaminated water, especially high concentration of petroleum and heavy metals, leads to water pollution and fish poisoning in the studied aquatic ecosystems (Pipeline and Hazardous Materials Safety Administration (PHMSA), 2008; Ahn and Jo, 2005). Etic cyclic hydrocarbons calm, even in low concentrations, may cause cancer and genetic mutations (Acton et al., 2002.). Given that local people are used to catch fish in estuaries as a source of food and livelihood, any toxicity in aquatic organisms, especially the fish and shrimps, threaten the region's health. Furthermore, contamination of groundwater with oil leaking on the soil surface may contaminate the water in the wells.

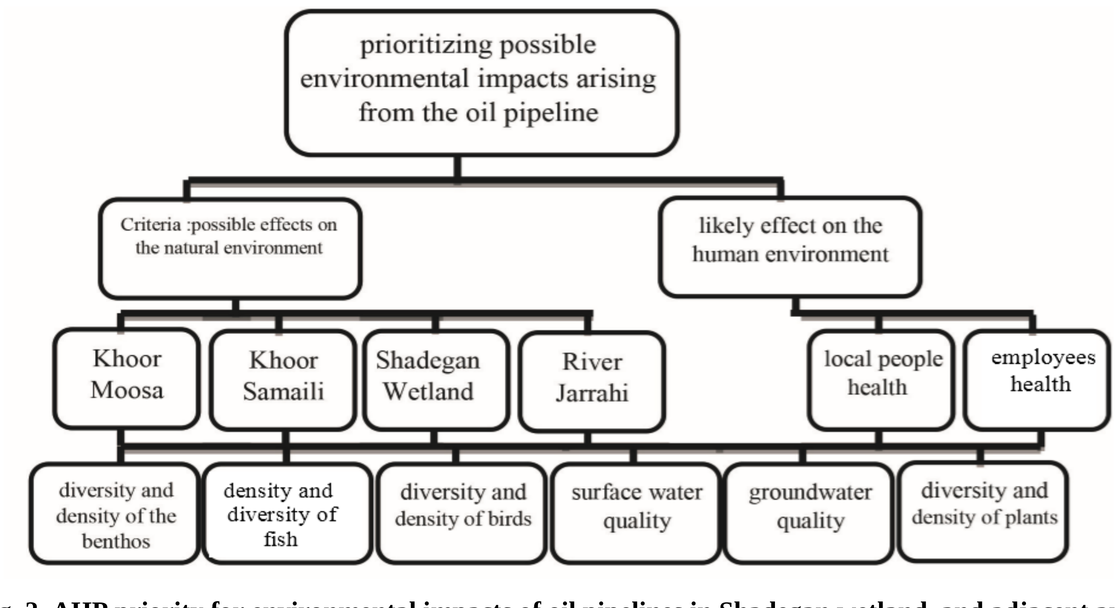

Fig. 2. AHP priority for environmental impacts of oil pipelines in Shadegan wetland, and adjacent area (First level-Goal; Second level-Criteria; Third level-Criteria; Fourth level-Opinions)

To prioritize the probability of environmental risk, the preferred matrix was determined for each level to high level, and is given a number (Mirghafouri and Ali Kousha, 2015). Tables (1) to (8) present matrix priority for likely impacts of pipelines on studied environmental. As for two main criteria, namely natural and man-made environment, the likelihood of environmental impact (i.e. the effect on natural environment) was a priority risk, weighting 0.670, and primarily important. In the natural environment, parameters of physical environment were considered, based on other parts of the environment, including biological environment; consequently, there was a likely environmental risk from the pipelines for physical environment elements, such as the effect on water quality in all aquatic ecosystems in the region. The major environmental risk for pipelines in the biological environment were the effects on behavior and structure of aquatic habitats as well as diversity and density of aquatic species (Mathews, 2013).

In the study area, both the local people and pipelines staff did not use the water from the wetland and creeks for drinking purposes; however, consequences of human environment as well as the threat to people's health probably arose from fishing, aquaculture and consumption of fish and shrimp, and a variety of contaminated oil in the diet. Hence, the effect was more likely manifested in natural environment parameters. The pair-wise comparison matrix for the corresponding effect on the human environment weighed 0.330.

Table 1. Priorities compared to the goal

	Impact on natural environment	**Impact on human environment**	**Priority**	**Weight**
Impact on natural environment	1	2	1	0.670
Impact on human environment	1: 2	1	2	0.330

Table 2. Priorities of natural environment

	Khoor Moosa	**Khoor Samaili**	**River Jarrahi**	**Shadegan wetland**	**Priority**	**Weight**
Khoor Moosa	1	1: 2	7	5	2	0.322
Khoor Samaili	2	1	9	7	1	0.551
River Jarrahi	1: 7	1: 9	1	1: 2	4	0.042
Shadegan wetland	1: 5	1: 7	2	1	3	0.075

Table 3. Priorities of man-made environment

	Effect on health of staff	**Effect on health of indigenous people**	**Priority**	**Weight**
Effect on staff health	1	3	1	0.750
Effect on health of indigenous people	1: 3	1	2	0.250

Table 4. Priorities of Khoor Samaili

	Benthic communities	Fishes	Aquatic plants	Birds	Surface water quality	Groundwater quality	Weight
Benthic communities	1	4	7	5	1: 2	8	0.302
Fishes	1: 4	1	6	4	1: 4	7	0.151
Aquatic plants	1: 7	1: 6	1	1: 4	1: 4	1	0.042
Birds	1: 5	1: 4	4	1	1: 5	4	0.071
Surface water quality	2	4	4	5	1	9	0.389
Groundwater quality	1: 8	1: 7	1	1: 4	1: 9	1	0.045

Table 5. Priorities of Khoor Moosa

	Benthic communities	Fishes	Aquatic plants	Birds	Surface water quality	Groundwater quality	Weight
Benthic communities	1	1:2	8	4	1: 2	8	0.204
Fishes	2	1	8	4	1: 3	9	0.252
Aquatic plants	1: 8	1: 8	1	1: 4	1: 5	1	0.049
Birds	1: 4	1: 4	4	1	1: 6	4	0.082
Surface water quality	2	3	5	6	1	8	0.392
Groundwater quality	1: 8	1: 9	1	1: 4	1: 8	1	0.021

Table 6. Priorities of Jarrahi River

	Benthic communities	Fishes	Aquatic plants	Birds	Surface water quality	Groundwater quality	Weight
Benthic communities	1	1	1	1	1	1	0.167
Fishes	1	1	1	1	1	1	0.167
Aquatic plants	1	1	1	1	1	1	0.167
Birds	1	1	1	1	1	1	0.167
Surface water quality	1	1	1	1	1	1	0.167
Groundwater quality	1	1	1	1	1	1	0.167

Table 7. Priorities of Shadegan Wetland

	Benthic communities	Fishes	Aquatic plants	Birds	Surface water quality	Groundwater quality	Weight
Benthic communities	1	1	1	1	1	1	0.167
Fishes	1	1	1	1	1	1	0.167
Aquatic plants	1	1	1	1	1	1	0.167
Birds	1	1	1	1	1	1	0.167
Surface water quality	1	1	1	1	1	1	0.167
Groundwater quality	1	1	1	1	1	1	0.167

Table 8. Priorities that affect the health of local people and pipelines staff

	Benthic communities	Fishes	Aquatic plants	Birds	Surface water quality	Groundwater quality	Weight
Benthic communities	1	1: 2	8	3	1: 3	1: 4	0.127
Fishes	2	1	7	3	1: 2	1: 3	0.175
Aquatic plants	1: 8	1: 7	1	1: 5	1: 6	1: 9	0.123
Birds	1: 3	1: 3	5	1	1: 3	1: 4	0.091
Surface water quality	3	2	6	3	1	1: 3	0.207
Groundwater quality	4	3	9	4	3	1	0.377

According to studies, Shadegan Wetland, being closest to the pipelines, was more vulnerable to pipelines contaminants (Zare Maivan, 2012). In addition, pipelines had been constructed by extracting the wetland. Thus, in the matrix to compare and prioritize potential risks against natural environment, this wetland was considered a priority with a weight up to 0.551.

In case of any contamination in Shadegan Wetland, the resultant pollution was transferred to the surrounding waters, including Khoor Moosa. Therefore, Khoor Moosa, the largest creek in the study area, along with other creeks originating from it, possibly suffered from considerable pipeline pollution, putting it in the second place with a relative weight of 0.322.

Khoor Samaili was located relatively far from the pipelines, yet thanks to many facilities related to pipes, it too faced low environmental risks, posed by the activities of the plan of the oil reservoirs. The possibility of environmental risk on this creek was in the third place, having a weight of 0.075. Finally, Jarrahi River, far away from the study area with very little chance of environmental consequences and risks had the least priority, weighing 0.042.

In a matrix for comparing the tests with regards to the influence on natural environment, in turn affecting the health status of region's employees, it was in the first priority, having a weight of 0.750, thanks to its proximity to the pipelines' location as well as its facing the risks and environmental pollutants,.

It is noteworthy that the closest population center in the study area was the city of Shadegan, located at a relatively large distance from the pipelines; therefore, harmful effects on the health of indigenous people were less likely than the region's employees.

The matrix prioritized the options in comparison to the next higher level of the hierarchy, with respect to the ranks, given on the basis of diversity and density parameters of living in the aquatic environment, like the communities of benthic, fish, birds, and aquatic plants, as well as the effect on surface water quality.

In a test comparison matrix for environmental parameters of Shadegan Wetland, major activities, intended for the construction and operation phase such as dredging, layering, waste discharge, and potential oil spill, reduced water quality of the wetland. In turn, reduced water quality in the wetland affected water-dependent lives and communities of the ecosystem. As a consequence, environmental hazards for water quality, caused by oil pipes, were placed first in Shadegan Wetland, having a relative weight of 0.389.

In the second priority and with a weight of 0.302, there was the pair-wise comparison matrix for options, owing to the diversity and density of benthic communities (benthos). The Macrobenthic in the area were either destroyed through dredging and earthworks or difficult to find nutrition due to a change in the substrate. In either case, their population declined. In addition, any outflow of oil compounds at the time of loading, pipe clearing, and spills had the sediments receive a lot of fuel. Part of the oil ended up as a thin layer on the floor, creating an anaerobic environment. The remaining oil in the water, on the other hand, reduced the power chemical feeding in demersal, like the bivalves.

Benthoses are choice feeds for the fish (Ganoulis, and Simpson, 2006). Therefore, any shortage or lack of them introduces food poverty in an ecosystem. In the matrix, the diversity and density of fish in Shadegan Wetland (Ramsar Convention Secretariat, 2013) had the third priority with a weight of 0.151. Dredging in a wetland's bed along with an increase in suspended solids (SS) of the water blocked fish gills, leading to some disorders in their respiratory system, ulcers in their tissues, and reduced quality suitable for their reproduction and spawning areas. Also, oil leaks into the water reached the adipose tissue of the fish in the long run, making changes in their behavior, immigration forms, fertility rates, habitat, and food supplies.

The effect of the density and diversity of waterfowl and waders, with a weight of 0.071, was ranked in the fourth priority. Thanks to the conditions, governing the pipelines' implementation to allow certain species of birds compatible with living conditions of the wetland, the traffic was very low in this area. It was anticipated that pipeline activities could possibly have harmful effects on birds to deploy oil pipes, through pollution and decreased water quality. In terms of oil spills and fish mortality, nutrition adversely affected different bird species, dependent on aquatic ecosystems (Hosseini Alhashemi et al., 2011). Moreover, oil pipes diminish the protective properties of birds' waterproof feathers, blocking their respiratory tract, and eventually choking them. If ingested, petroleum products lead to stress reactions, a decrease in reproduction of both sexes, and damaged red blood cells in the blood, causing anemia, since the irritation of the digestive tract changes the fat in the liver, enlarges adrenal glands, and kills the tissues (Dawotola et al., 2010).

It should be considered that the risk of adverse effects, caused by the birds, is quite insignificant since the probability of oil leak in the pipelines as well as water pollution was low and birds' contact surface with water was small, not to mention the decreased quality of their habitats along with the fact that they could simply migrate to other habitats. Therefore, this was put in the fourth priority in the matrix, taking precedence over other environmental factors. The impact on aquatic plants and groundwater quantity weighed 0.042 and 0.045, respectively, which sent them to the last priorities.

In comparison matrix test for possible effects on environmental parameters of Khoor Moosa, the probability of an impact on this creek's water quality was in the first place, with a weight of 0.392. Possible adverse effects, resulting from the implementation of the Khoor Moosa, were similar to Khoor Samaili. The difference was that only the Khoor Moosa underwent dredging operations, hence the effects of this activity were not likely to be listed as biotic and abiotic factors of Khoor Moosa.

Considering that tides' movements in the creeks (Galalizadeh et al., 2016) result in emissions in the surrounding waters, in the event of any oil leak or spill, there was a possibility of emissions and pollution in Khoor Moosa. Due to high biological diversity in the creeks, which was the main characteristic of other estuaries, pollution and its impacts played an important role in the quality of their environment.

The probability matrix effects of environmental parameters of Jarrahi River shows that this river was located in a relatively large distance from the pipelines, thus the water of wetland and creeks of this area were not completely associated with the river, itself. Therefore, the impact on water quality as well as biotic factors' influence on the river was not likely. So in the matrix, abiotic and biotic effect on all parameters, specified in Jarrahi River, weighed 0.167. This applies to Khoor Samaili, too, meaning that despite the protection and conservation of most coastal ecosystems, along with animal species, aquatic plants, and related habitat, local to these areas, the potentiality to cause environmental hazards arising from the lagoon was not likely as this zone lay far away from the pipelines, having a weight equal to 1.

The matrix prioritized options for the final effect on indigenous and local people's health, along with that of the pipelines workers in the area. As such, the influence on the quality of surface and ground water, were put in the first and second places, respectively, having a weight of 0.377 and 0.207. The impact on fish, benthic communities, and birds, weighed 0.175, 0.127, and 0.091, respectively, getting the third and fourth places.

There was no effect on health, given that the local people, i.e., both the workers and indigenous people residing in the area, did not provide their drinking water from the region's creeks. Therefore, water pollution, caused by possible contamination of water bodies in these ecosystems, only affected poisoning through catching fish from waters, riddled with oil and heavy metals, and by feeding them to local people.

Only through oil spills along pipelines' paths, was it likely for groundwater quality to be reduced. In terms of groundwater pollution, since the people of the region used it as a source of drinking water, there was a risk of side effects on their health. The area, around oil pipelines, had been insulated by concrete walls and basins, thus there was a low risk for oil spills from the pipes.

Table (9) gives the results for quantification of environmental impacts, caused by the pipelines, showing that dredging activities and fuel outflows from pipelines and tankers had the greatest impact on environmental parameters in the study area. According to Table 9, the severity of the impact on diversity and density of benthos and various fish species were in the highest level.

Scoring showed that the harmful environmental effects of oil reserves at the docks of Mahshahr Port on water quality of Khoor Samaili posed highest level of risk. Yet, the effect on diversity and density of benthic communities as well as fish species in Khoor Samaili and Khoor Moosa had medium risk level, with other environmental parameters, related to aquatic habitats in the study area, having very low to low risk levels. Table (10) classifies the degree of risk and environmental risk levels for each environmental parameter.

Recommendations

Risk control strategies demonstrate the potential opportunities to promote protection of environment and the population, affected by the pipelines. Control measures can be taken to help changing the design, construction, operation, and maintenance of these projects (Nasehi et al., 2013).

The aim of these measures will be to reduce risk from high levels to lower levels and, in fact, reduce the risk and likelihood of their occurrence (Achebe, 2012). Appropriate methods of management, which is at the same time environmentally-friendly, must be put in good use in order to manage environmental risks. In addition to the purposes and requirements of the scheme, this will reduce the environmental hazards, caused by the interaction between natural phenomena and activities plan, being justified in economic and technical terms.

Preparing and implementing a management system to take some measures for controlling the risk is part of the risk management program, being its primary purpose, (Khaleghian et al., 2013; Taghinia Hejabi et al., 2011). A program to manage environmental risk will be a component of environmental risk assessment, which tries to risk control, and develop decision-making and implementation stages of risk management under consideration, needed be implemented in the process of carrying out development projects, especially in the wetlands and the environments, around them.

Risk management programs should be organized processes to identify specific actions, leading to lower or stop the risk at the current level (Whanda et al., 2015; Vesali Naseh et al., 2012). In cases where risk control does not commensurate with environment management or cannot perform prevent its occurrence, it should be provided with necessary preparations to deal with possible consequences of its occurrence (Venugopal, 2009).

Some general suggestions to implement corrective actions and mitigate risk in this study, for effective protection of Shadegan Wetland as one of the Iranian wetland areas, can be expressed as follows:

A - Organizing water pollutants

- Observe the schedule for earthworks

- Prepare response plans to deal with spills of hazardous materials, oil and lube, fuel, etc.

- Control and monitor oil spills from pipelines, pumping oil tanks stationed in the Port

- Use physical barriers in place to prevent waste entry in appropriate activities

B - Accounting factors for soil pollution

- Monitor liquid waste discharge into the soil, such as fuel, oil, hydraulic oil, etc.

- Inspect the track and privacy in order to implement the plan and inform the chief contractor on the project's legal privacy

- Deploy tanks to collect leaks from the drain along with the channels

- Removal of contaminated soil in the event of oil spills on the soil surface

C - Correcting the destructive factors of fish

- Control and monitor illegal discharge of ballast water of oil tankers, passing through them to the dock at the port

- Fully review the diversity and expansion benthic communities and fish in the area, and continuously monitor the dependent creatures

- Monitor the operations, migration, distribution, diversity of species, density, spawning season, nesting, and fertility for aquatic species, along with water, such as bird species in the area of mud, and tides in the creeks and estuaries species of birds that have conservation value

- Monitor dredging and layering activities

D - Regulatory risk factors on health

- Determine the signs and symptoms of privacy and oil pipelines, hazardous facilities design, and symptoms related to safety issues in the area

- Inform local people and employees in the region about the case of water contamination and poisoned fish

- Hold training courses in all levels about the consequences of water pollution and how to reduce it along with the ways of dealing with accidents such as oil spills, fires, and explosions

Table 9. Scoring for the severity of the environmental impacts of the project

Environmental consequences/ Activities		Dredging	Discharge of dredged material	Leaking fuel from tanks	Leaking fuel from pipeline	Extraction of the estuary	Discharge ballast water of ships	Ei (xi)
Shadegan wetland	Effect on the diversity and density of benthos	9	5	8	8	7	6	43
	Effect on the diversity and density of fish	7	7	8	8	5	7	42
	Effect on the diversity and density of aquatic plants	6	6	5	5	6	4	32
	Effect on the diversity and density of birds	3	3	4	4	2	6	22
	Effect on the quality of surface water	6	7	8	8	6	7	42
Khoor Moosa	Effect on the diversity and density of benthos	3	3	7	7	2	6	22
	Effect on the diversity and density of fish	3	3	7	7	3	7	30
	Effect on the diversity and density of aquatic plants	2	2	4	4	2	4	18
	Effect on the diversity and density of birds	2	2	3	3	2	6	18
	Effect on the quality of surface water	5	6	7	7	5	7	37
Khoor Samaili	Effect on the diversity and density of benthos	1	1	1	1	1	1	6
	Effect on the diversity and density of fish	1	1	1	1	1	1	6
	Effect on the diversity and density of aquatic plants	1	1	1	1	1	1	6
	Effect on the diversity and density of birds	1	1	3	3	1	3	12
	Effect on the quality of surface water	1	1	1	1	1	1	6
River Jarrahi	Effect on the diversity and density of benthos	1	1	1	1	1	1	6
	Effect on the diversity and density of fish	1	1	1	1	1	1	6
	Effect on the diversity and density of aquatic plants	1	1	1	1	1	1	6
	Effect on the diversity and density of birds	1	1	2	2	2	2	10
	Effect on the quality of surface water	1	1	1	1	1	1	6

Table 10. Determination of the degree of environmental risk levels in the study area

Water systems	Environmental impact	Probability Wi	Intensity Ei (xi)	Degree of risk Rk	Level of risk
Shadegan wetland	Effect on the diversity and density of benthos	0.302	43	12/6/98	High
	Effect on the diversity and density of fish	0.151	42	6.342	Average
	Effect on the diversity and density of aquatic plants	0.042	32	1.344	Very weak
	Effect on the diversity and density of birds	0.071	22	1.562	Very weak
	Effect on the quality of surface water	0.389	42	16.338	Very high
Khoor Moosa	Effect on the diversity and density of benthos	0.204	28	5.712	Average
	Effect on the diversity and density of fish	0.252	30	7.56	Average
	Effect on the diversity and density of aquatic plants	0.049	18	0.882	Very weak
	Effect on the diversity and density of birds	0.082	18	0.882	Very weak
	Effect on the quality of surface water	0.392	37	14.504	High
Khoor Samaili	Effect on the diversity and density of benthos	0.167	6	1.002	Very weak
	Effect on the diversity and density of fish	0.167	6	1.002	Very weak
	Effect on the diversity and density of aquatic plants	0.167	6	1.002	Very weak
	Effect on the diversity and density of birds	0.167	12	2.004	Weak
	Effect on the quality of surface water	0.167	6	1.002	Very weak
River Jarrahi	Effect on the diversity and density of benthos	0.167	6	1.002	Very weak
	Effect on the diversity and density of fish	0.167	6	1.002	Very weak
	Effect on the diversity and density of aquatic plants	0.167	6	1.002	Very weak
	Effect on the diversity and density of birds	0.167	10	1.67	Very weak
	Effect on the quality of surface water	0.167	6	1.002	Very weak
Effect on groundwater quality		0.052	15	0.78	Very weak

CONCLUSION

Risk, or consequence, indicates the possibility of a hazard to occur in a given time period, which based on probability is very likely for multiple risk ratings (Rezazadeh, 2004). This study employed the method of ranking the potentials for environmental impacts via AHP. Since the creeks are the interface between land and sea, taken from the latter during the low tide, they carry pollution to the waters around. So, on the second level in a hierarchical structure, possible impacts on natural habitats are divided into four sub-criteria: impact on Khoor Samaili, Khoor Moosa, Jarrahi River, and Shadegan Wetland. As for man-made habitats, they are divided into two sub-criteria: impact on the health of indigenous people, and the impact on the health of pipelines employees based in the area. In the end, the environmental parameters, being likely outcomes, have been divided as options. At this level, the probability of impact on any of the environmental parameters outlined above, such as the impact on the diversity and density of aquatic plants, fish, populations of birds, and the influence on surface water quality in the study area, have been prioritized and weighted.

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