Environmental Risk Assessment of Gotvand-Olia Dam at Operational Phase Using the Integrated Method of Environmental Failure Mode and Effects Analysis (EFMEA) and Preliminary Hazard Analysis

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Introduction

Gotvand-Olia as one of the largest constructional projects in Iran has been constructed on the Karoun River, between Masjed Soleiman and Gotvand Regulatory dam in Khuzestan Province. It is situated in 382.8 km away from the river estuary at a distance of 25 km north of Shoushtar city. This study was conducted to identify and assess the risk of Gotvand-Olia dam on the environment at the operational phase. As a part of the management of water resources, the dam is one of the most important structures playing a major role in the regulation of surface flows, especially in the areas that have poor spatial and temporal distribution of rainfalls. Due to developments in dam construction in the world and particularly in Iran, the need to assess the environmental impacts of dams is very important. Environmental risk assessment is able to establish a relationship between the impacts of unwanted events with those that are not catastrophic. The quantitative risk assessment provides evident objectivity and transparency in the assessment of the impacts.

Material and methods

The current study aims at assessing the risk of Gotvand-Olia dam at the operational phase. Accordingly, after reviewing the relevant literatures, field studies, and interviewing with expertise and research team, a questionnaire was designed to identify the potential risks during the operational phase. According to the studies conducted in the field of dam risks in the world and particularly in Iran as well as the technical and environmental reports on the Gotvand-Olia dam, the risk factors of the operational period were identified at first using the checklist of the PHA Method and were then assessed by EFMEA.

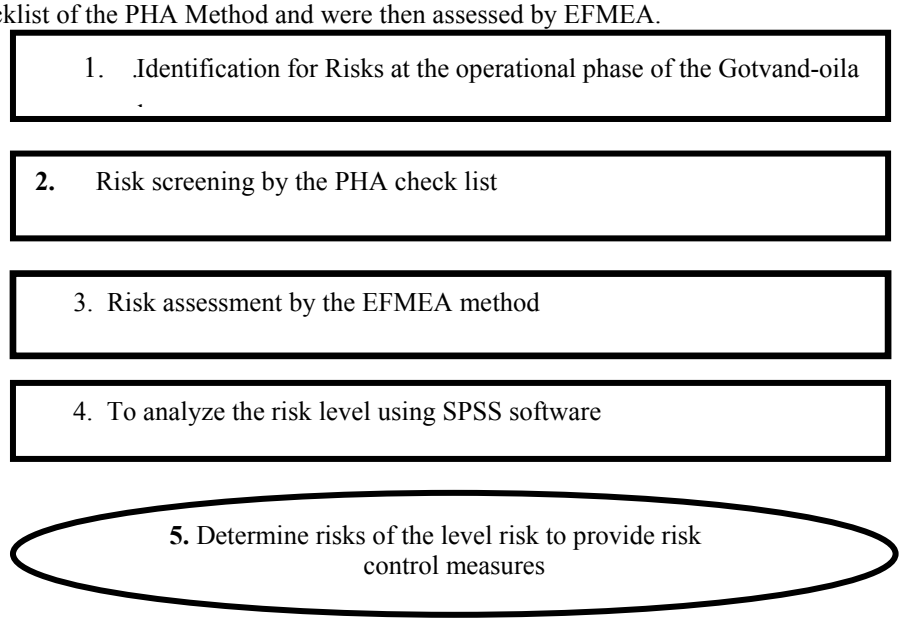

Figure 1. Study implementation of the risk assessment of the Gotvand-oila

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In FMEA, techniques to obtain have degrees of severity, probability, and extent of contamination. After obtaining, the three number can be calculated through the formula Risk Priority Number (RPN)= Severity of risk × Event Risk × Extent of contamination. Subsequently, a list of potential risk factors at the operational phase was included in the questionnaire and placed at disposal of the individuals who were expert on dam and environment. Afterwards, considering the current situation of the study area, overall risk options at the operational phase (21 cases) were classified in the form of physicochemical, biological, socioeconomic, cultural, health-safety, and natural hazards using the PHA checklist. To make a decision on acceptance or rejection of risks, statistical methods were applied to prioritize risk factors and specify their hazardous level due to lack of prioritization of the risks in EFMEA. Accordingly, the high-level risks were identified.

The study implementation of the risk assessment of the Gotvand-oila was shown in the figure 1.

Results and discussion

According to the identified risks, it can be concluded that reservoir inundation, extraction of borrow materials, transportation of vehicles and machineries, recreation and tourism as well as construction of infrastructure facilities are hazardous activities at the operational phase.

The risks at the operational phase of the Gotvand-oila by the FMEA method were shown in Table 1.

Table 1. Risks at the operational phase of the Gotvand-oila by the FMEA method

Level Risk	RISK Prior Number	Risk	series
H	320	Water salinization due to salt dome	1
H	288	Erosion & sedimentation in downstream of the dam	2
H	256	Generation of waste water and effluent by tourism & recreation	3
H	256	Generation of solid waste by tourism & recreation	4
H	256	Generation of waste water and in infrastructures	5
H	256	Generation of solid waste and industrial waste in infrastructures	6

The obtained results suggest that the highest RPN equal to 320 belongs to water salinization occurred due to the existence of salt domes. While borrowing materials, the highest RPN (tantamount to 288) is belonged to erosion and sediment. The risk level is high. In transportation using vehicles and machineries, the highest RPN (equal to 216) is allocated to the vehicle exhaust emissions. The risk level is moderate. Among tourism and recreational activities, the highest RPNs were assigned to the generation of wastewater and effluent as well as solid waste, both with the same RPN of 256. The risk level is high. Amongst activities related to the construction of infrastructures, the highest RPN (256) belongs to the generation of industrial wastewater and effluent. The risk level is high. A total number of 19 environmental risks were assessed and weighted by the EFMEA. Afterwards, they were analyzed by SPSS Software. Accordingly, upper and lower risk limits were determined 237.8 and 116, respectively. Majority of the risks identified at the operational phase of the Gotvand-Olia dam can be classified in medium-level category which devoted itself to 58% of the whole. In this respect, the low (L) and high (H) level risk categories comprising 10% and 32% of total risks, respectively, have the lowest share.

Conclusion

The highest RPN (320) belongs to water salinization occurred due to the dam inundation while the lowest RPN (90) is related to providing an appropriate environment for growth and reproduction of insects (Anopheles) as well as soil compacting as a result of the agricultural development and the transportation of heavy machineries. The activity of Gachsaran formation leads to the depletion of soil impregnated with salt to the river that its impacts can be characterized in terms of salinity, total dissolved solids (TDS), total suspended solids (TSS), and electrical conductivity (EC). Given the importance of such a formation at the reservoir margins, the changes in the quality of river water at the operational phase can be justified. In this study, it is quite necessary to pay enough attention to the discharge of the Karoun River as well as regional droughts. It is also necessary to

consider a suitable place to dump soils containing salts extracted from upstream of the dam. In a second evaluation after the implementation of control and corrective measures, the highest risk of erosion and sedimentation downstream of the dam removal borrow materials (RPN= 168, a moderate risk level (M)) and the lowest risk is related to the oil spill equipment and the use of vehicles and machinery transporting operations (RPN=36, with a low risk level (L)).

Implementation of control and corrective measures of risks at the operational phase of Gotvand-oila was shown in Tabel 2.

Table 2. Implementation of control and corrective measures of risks at the operational phase of the Gotvand-oila

Corrective measures	Risk
Estimation assessment ecologic risk by attention to the environment impacts of Gachsaran formation. Daily performance testing of water river quality. Daily sampling and monitoring of water river quality.	Water salinization due to salt dome
Simulation erosion and salinization in the reservoir dam zone and precaution long time impacts. Program codification for clearing and correction borrow materials excavated in the Imam ZadeZaid zone. Program codification for green space development in the site.	Erosion & sedimentation in downstream of the dam by removal borrow materials

Keywords: EFMEA, Gotvand-Olia dam, environmental risk assessment, Khuzestan province, operational phase, PHA, reservoir dam, risk, risk prioritization.