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Analyzing the Critical Risk Factors in Oil and Gas Pipelines Projects Regarding the Perceptions of the Stakeholders

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Abstract

Oil and Gas Pipeline (OGP) projects face a wide range of Risk Factors (RFs) at the design, construction and operational stages of the project particularly because of Third Party Disturbance (TPD) in the insecure environments. The lack of risk information and the root causes of pipelines' failures are hindering the efforts of managing these risks. Therefore, this paper aims to analyze the existing risk factors and recommend an effective Risk Mitigation Methods (RMMs) based on a holistic approach from the prospect of stakeholders' interest. An investigation was carried out to identify the critical RFs and existing RMMs in different circumstances to overcome the problem of the historical records about the RFs and RMMs. The findings of the literature review were used to design a questionnaire survey to analyze RFs and evaluate the "usability and effectiveness" of the RMMs. The RFs were ranked by using Risk Index (RI) method based on the probability and severity levels of each RF. The survey results revealed that sabotage and terrorism as part of TPD, corruption and insecure areas are the most critical RFs, whereas, anti-corrosion efforts, underground pipelines and technologically advanced risk monitoring systems are the most effective RMMs. These ranking are vary based on the occupation of the stakeholder in OGPs; like the planners and the researchers said corruption is the most critical RF, and the researchers said that the advance risk monitoring systems are the most effective RMM.

Keywords: Oil and gas pipelines (OGPs), risk analysis, Stakeholders' perceptions, Risk Mitigation Methods (RMMs)

1. Introduction

Oil and Gas Pipelines (OGPs) projects must be planned, designed, installed and operated in ways that comply with the safety requirements. However, several risks are hindering the safety of these projects such as external sabotage, corrosion [1], design and construction defects, natural hazards, operational errors and more risks [2-4]. Mitigating OGPs' RFs is a valuable knowledge because it minimizes the economic losses from disturbing the business of oil export; as well as, it ensures the safety of the projects' stuff and the people that live near the pipelines.

The efforts of mitigating OGPs RFs are significantly require verified historical records about the pipelines' accidents and failure reasons [5,6]. Moreover, the probability of RFs must be accurately analyzed and ranked because dealing with each RF as the most severe risk results resources wistful. However, the existing risk analysis methods are not accurate enough to analyze the external sabotage of the pipelines when there is no database "historical records" about such risk [7-9]. Additionally, an accurate evaluation of the Risk Mitigation Methods (RMMs) in term of their degrees of "usability and effectiveness" degrees of mitigating the RFs helps the decision makers while they are considering their plans to mitigate OGPs' RFs. Accordingly, the inaccurate analyses of OGPs' RFs and inaccurate evaluation of the RMMs are hindering any efforts of risk mitigation in these projects. Particularly, in the troubled and developing

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countries because these highlighted problems are crucial and associate with OGP projects in these countries. Hence, there is a vital need to help the stakeholders to improve the safety for these projects by providing the required data for OGPs risk management such as the "probability and severity" levels of the RFs and the "usability and effectiveness" of the RMMs.

The aim of this paper is to analyze the RFs and evaluate the RMMs in OGPs projects more holistically and effectively base on qualitative documents analysis and a questionnaire survey. Moreover, the up-to-date data about the RFs and RMMs can help the stakeholders to improve the safety of GOPs continuously.

Iraq is selected as the case study in this paper because its oil reserves is the fifth-largest oil reserves in the world [10]. As well as, it are estimated that Iraq's gas reserves are amongst 10^{th} to 13^{th} largest reserves globally, in addition to vast potential reserves for further discoveries [11]. At the present time, a vast range of RFs threatens OGPs project in Iraq and the inadequacy of mitigating the RFs hinders the business of oil export which is in high demand after 2003.

Moving forward in this paper, section 2 consists a review about identifying pipelines' RFs and RMMs. Section 3 explains the research methodology. The results of analyzing the RFS and evaluating RMMs are interpreted in section 4. Section 5 discusses this paper' findings. Finally, section 6 shows the conclusions.

2. Identifying the Risk Factors (RFs) and Risk Mitigation Methods (RMMs) in OGPs Projects

Qualitative documents analysis were carried out to identify the RFs in OGPs projects in different circumstances, especially in the insecure countries. Thirty RFs were identified based on the findings of the literature review that are shown in Table 1.

Table 1. The identified RFs in OGPs projects from the literature review.

RFs	Author
Thieves	12
Publics' legal and moral awareness about OGPs projects	7
Peoples' education and poverty levels in OGPs areas	12
Leakage of sensitive information	13
Threats to staff	14
Sabotage and Terrorism	12
Accessibility of pipelines	15
Conflict over land ownership	16
Insecure areas	15
Vehicle accidents	7
Animal accidents	17
Geological RFs	18
Lack of regular inspections and maintenance of OGPs	12
The opportunity to sabotage exposed pipelines "aboveground pipelines"	14
Lack of compliance with the safety regulations	18
Weather conditions and natural disasters	12
Inadequate risk management approaches	12
Non-availability of warning signs	12
Weak ability to identify and monitor the RFs	12
Corrosion and lack of anti-corrosive action	12
Shortage of modern IT services	12
Design, construction and material defects	18
Hacker attacks on the operating or control systems	15
Operational errors	12
Corruption	12
Few researchers about this problem	12
Lawlessness	7
Lack of proper training schemes	12
No proper attention from the stakeholders	12
Lack of historical records and data about RFs	12

These wide investigations helped to overcome the problem of data scarcity about the RFs in OGPs projects in Iraq. Accordingly, a number of RMMs was suggested to mitigate RFs like anti-corrosion and cathodic protection; laying the pipelines underground rather than aboveground; modern equipment to monitor the RFs; proper inspection and maintenance; proper training for the stuff about mitigation the RFs in their projects; avoid insecure areas; anti-terrorism planning and design; avoid the registered RFs; protective barriers; government-public cooperation; and warning signs near the pipelines and marker tape above the pipeline.

Table 1 cannot give accurate information about the "probability and severity" of the RFs. As well as, the suggested RMMs need to be evaluated regarding their degrees of "usability and effectiveness" to mitigate the RFs in OGPs projects. Therefore, the filed investigations were required to analyze the contents of OGPs' safety in Iraq by distributing a questionnaire survey.

3. Methodology

An industry-wide questionnaire survey was designed based on the findings of the literature review (see Table 1) in order to analyze the RFs based on the perceptions of the stakeholders in OGPs in Iraq. In this survey, the RMMs will be evaluated too. The respondents were promised that the data will be anonymity analyzed.

The first question was asked about the occupation of the respondents in OGPs projects. The survey had two questions to analyze the RFs as follows. The first question was addressed to analyze the probability of occurrence of the 30 RFs on a five-point rating Likert scales which is "rare, unlikely, possible, likely and almost certain". The second question was analyze to evaluate the severity of the RFs on a scale "negligible, minor, moderate, major and catastrophic". Similarly, the survey had two questions to evaluate the RMMs as follows. The first question was asked about evaluating the usability of the RMMs on a scale "rare, unlikely, possible, likely and almost certain". The second question was about evaluating the effectiveness of RMMs on a scale "ineffective, slightly effective, moderately effective, very effective, and extremely effective".

The descriptive statistical analysis in Statistical Package for the Social Sciences (SPSS) software was used to determine the values of Risk Probability (RP) and Risk Severity (RS) for each RF by calculating the mean of the five point Likert scales. The degree of impact for each RF was found by using Risk Index (RI) method as explained in Eq. (1) [19]. The RFs were ranked regarding their RI values. In the same way, the usability and the effectiveness of the RMMs were found.

$$RI = (RP \times RS)/5 \quad (1)$$

4. Results

The survey was distributed online and it was targeting the owners, clients, researchers, consultants, planners, designers, and construction, operators, maintenance workers in Iraq's OGPs projects. 198 respondents from stakeholders have answered the survey's questions as shown in

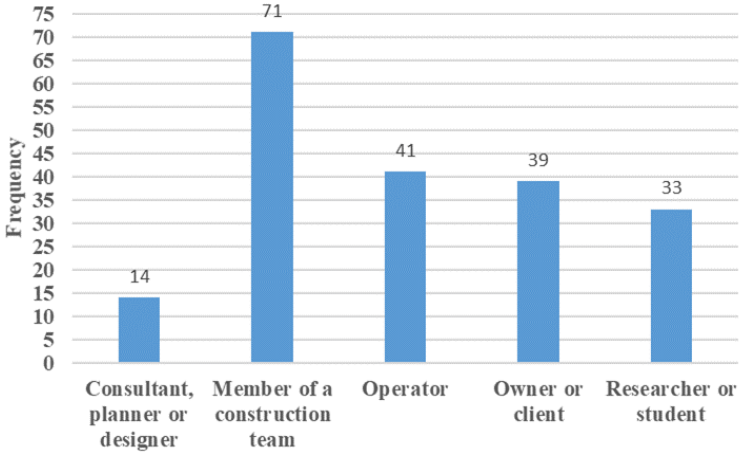

Fig. 1: Participants' demographic information.

Fig 1. As shown in Fig. 1, the majority of the participants were members of construction teams, followed by the operators, owners or clients, researchers or students and the less majority was for the consultants, planners and designers.

The Cronbach's alpha correlation coefficient factor was calculated to measure the reliability level of the survey [20,21]. Commonly 0.7 indicates a minimum level of reliability [22]. Table 2 shows the Cronbach's alpha coefficient

factor case processing summary. The reliability test is not applicable for question 1 because it was asking about the participants' occupation in OGPs projects.

Table 2. Cronbach's alpha coefficient factor case processing summary for the survey overall and by participants' occupation.

Case Processing Summary	Valid %	Items	α
All the questionnaire's questions	100	95	0.910
The question about RP (survey overall)	100	30	0.919
The question about RS (survey overall)	100	30	0.863
The question about the usability of RMMs (survey overall)	100	12	0.867
The question about the effectiveness of RMMs (survey overall)	100	12	0.792
a consultant, planner or designer	100.0	95	0.863
a member of a construction team	100.0	95	0.892
an operator	100.0	95	0.927
an owner or client	100.0	95	0.917
a researcher or student	100.0	95	0.899

Based on the occupations of the stakeholder in OGPs projects in Iraq, Table 3, Table 4 and Table 5 show the results of calculating the RP, RS and RI of each RF respectively. Table 6 shows the ranking of the RFs based on their values of RI. The usability and effectiveness of the RMMs are shown in Table 7 and Table 8 respectively. Please note in these tables means the whole participants; (I) means the consultants, planners and designers; (II) means the construction workers; (III) means the operation and maintenance workers; (IV) means the owner and client; and (V) means the researchers.

Table 3. The probability of the risk factors by participants' occupation.

RFs	(Risk Probability) RP					
	Total	I	II	III	IV	V
Terrorism & sabotage	3.995	3.357	3.958	4.195	4.000	4.091
Corruption	3.980	4.000	3.986	3.878	3.846	4.242
Insecure areas	3.717	3.286	3.634	3.805	3.769	3.909
Low public legal & moral awareness	3.712	4.000	3.761	3.561	3.513	3.909
Thieves	3.692	3.214	3.845	3.659	3.564	3.758
Corrosion & lack protection against it	3.687	3.429	3.648	3.390	3.795	4.121
Improper safety regulations	3.687	3.643	3.662	3.561	3.872	3.697
Exposed pipelines	3.667	3.429	3.437	3.854	3.897	3.758
Shortage of the IT services & modern equipment	3.667	3.643	3.592	3.585	3.615	4.000
Improper inspection & maintenance	3.657	3.571	3.606	3.537	3.769	3.818
Lack of proper training	3.646	3.571	3.761	3.439	3.462	3.909
Weak ability to identify & monitor the threats	3.631	3.571	3.577	3.561	3.692	3.788
The pipeline is easy to access	3.631	3.571	3.563	3.732	3.538	3.788
Limited warning signs	3.626	3.429	3.648	3.341	3.974	3.606
Little researches on this topic	3.621	3.429	3.789	3.366	3.359	3.970
Lawlessness	3.606	3.786	3.676	3.268	3.795	3.576
Lack of risk registration	3.566	3.214	3.606	3.390	3.615	3.788
Stakeholders are not paying proper attention	3.530	3.286	3.676	3.439	3.462	3.515
Conflicts over land ownership	3.495	3.571	3.451	3.659	3.667	3.152
Public's poverty & education level	3.449	3.357	3.521	3.439	3.256	3.576
Design, construction & material defects	3.333	2.429	3.254	3.293	3.385	3.879
Threats to staff	3.323	2.714	3.394	3.268	3.410	3.394
Inadequate risk management	3.227	2.929	3.183	2.976	3.436	3.515
Operational errors	3.101	2.857	3.042	2.878	3.205	3.485
Leakage of sensitive information	2.980	2.643	3.070	2.707	2.949	3.303
Geological risks	2.747	2.714	2.662	2.537	2.795	3.152
Natural disasters & weather conditions	2.652	2.429	2.606	2.537	2.692	2.939
Vehicles accidents	2.465	2.357	2.380	2.293	2.333	3.061
Hacker attacks on the operating or control system	2.237	1.929	2.268	2.024	2.179	2.636
Animals accidents	1.894	1.929	1.986	1.561	1.821	2.182

Table 4: The severity of the risk factors by participants' occupation.

RFs	(Risk Severity) RS					
	Total	I	II	III	IV	V
Terrorism & sabotage	4.490	3.571	3.732	3.829	3.718	3.939
Corruption	4.323	3.500	3.958	3.57	3.692	3.636
Lawlessness	4.192	3.286	3.732	3.512	3.769	3.939
Insecure areas	4.106	3.286	3.634	3.659	4.000	3.606
Thieves	4.081	3.000	3.662	3.585	3.846	3.818
Corrosion & lack protection against it	3.990	3.357	3.676	3.683	3.641	3.697
Stakeholders are not paying proper attention	3.960	3.143	3.577	3.829	3.692	3.727
Improper safety regulations	3.949	3.214	3.592	3.488	3.872	3.667
Improper inspection & maintenance	3.924	3.357	3.746	3.610	3.641	3.394
Weak ability to identify & monitor the threats	3.899	3.000	3.690	3.488	3.487	3.758
Low public legal & moral awareness	3.859	3.357	3.535	3.244	3.590	3.727
Design, construction & material defects	3.848	3.571	3.549	3.390	3.179	3.333
Lack of proper training	3.773	3.500	3.408	3.098	3.410	3.697
Threats to staff	3.732	2.857	3.014	3.293	3.128	3.606
Lack of risk registration	3.697	2.857	3.042	2.854	3.077	3.455
Exposed pipelines	3.682	2.500	3.042	2.951	3.000	3.000
Limited warning signs	3.662	2.143	2.676	2.780	2.846	2.788
Shortage of the IT services & modern equipment	3.652	1.714	2.155	1.951	2.000	1.970
The pipeline is easy to access	3.646	3.571	3.732	3.829	3.718	3.939
Operational errors	3.611	3.500	3.958	3.537	3.692	3.636
Conflicts over land ownership	3.611	3.286	3.732	3.512	3.769	3.939
Little researches on this topic	3.571	3.286	3.634	3.659	4.000	3.606
Leakage of sensitive information	3.505	3.000	3.662	3.585	3.846	3.818
Public's poverty & education level	3.409	3.357	3.676	3.683	3.641	3.697
Inadequate risk management	3.399	3.143	3.577	3.829	3.692	3.727
Geological risks	3.182	3.214	3.592	3.488	3.872	3.667
Natural disasters & weather conditions	3.066	3.357	3.746	3.610	3.641	3.394
Hacker attacks on the operating or control system	2.970	3.000	3.690	3.488	3.487	3.758
Vehicles accidents	2.712	3.357	3.535	3.244	3.590	3.727
Animals accidents	2.020	3.571	3.549	3.390	3.179	3.333

Table 5. The index of the risk factors by participants' occupation.

RFs	(Risk Index) RI					
	Total	I	II	III	IV	V
Terrorism & sabotage	3.587*	3.021	3.579	3.909	3.405	3.669
Corruption	3.441	3.314	3.537	3.254	3.314	3.677
Insecure areas	3.053	2.722	2.928	3.267	3.035	3.222
Lawlessness	3.023	2.812	3.210	2.583	3.211	3.056
Thieves	3.013	2.388	3.206	2.998	2.906	3.029
Corrosion & lack protection against it	2.942	2.498	2.918	2.696	3.172	3.222
Improper safety regulations	2.912	2.810	2.899	2.797	2.958	3.070
Improper inspection & maintenance	2.870	2.755	2.742	2.829	3.015	3.078
Publics' legal and moral awareness	2.865	3.086	2.934	2.588	2.738	3.127
Weak ability to identify & monitor the threats	2.832	2.551	2.802	2.831	2.878	2.961
Stakeholders are not paying proper attention	2.796	2.629	2.972	2.583	2.716	2.855
Lack of proper training	2.751	2.551	2.807	2.634	2.574	3.080
Exposed pipelines	2.700	2.253	2.498	2.820	3.118	2.710
Shortage of the IT services & modern equipment	2.678	2.446	2.641	2.641	2.633	2.958
Limited warning signs	2.656	2.057	2.672	2.396	3.057	2.754
The pipeline is easy to access	2.648	2.245	2.550	2.858	2.613	2.824
Lack of risk registration	2.636	2.112	2.692	2.381	2.725	2.984
Little researches on this topic	2.586	2.057	2.796	2.348	2.343	2.983
Design, construction & material defects	2.566	1.839	2.410	2.538	2.760	3.033
Conflicts over land ownership	2.524	2.398	2.586	2.641	2.670	2.139
Threats to staff	2.481	1.900	2.687	2.312	2.518	2.468
The education and poverty levels in OGPs areas	2.352	2.398	2.500	2.332	2.071	2.384
Operational errors	2.240	1.837	2.185	2.008	2.482	2.556
Inadequate risk management	2.194	2.050	2.170	1.843	2.343	2.599
Leakage of sensitive information	2.089	1.774	2.171	1.756	2.117	2.462
Geological risks	1.748	1.551	1.605	1.670	1.749	2.273
Natural disasters & weather conditions	1.626	1.388	1.585	1.448	1.657	2.031
Vehicles accidents	1.337	1.010	1.274	1.275	1.328	1.707
Hacker attacks on the operating or control system	1.329	0.964	1.380	1.195	1.308	1.582
Animals accidents	0.765	0.661	0.856	0.609	0.728	0.860

*For example: RI for Terrorism & sabotage = 3.995 (RP from Table 3) × 4.490 (RS from Table 4) = 3.587

Table 6: The ranking of the RFs by participants' occupation.

RFs	Ranking the RFs					
	Total	I	II	III	IV	V
Terrorism & sabotage	1	3	1	1	1	2
Corruption	2	1	2	3	2	1
Insecure areas	3	7	7	2	7	4
Lawlessness	4	4	3	16	3	9
Thieves	5	15	4	4	10	11
Corrosion & lack protection against it	6	11	8	10	4	3
Improper safety regulations	7	5	9	9	9	8
Improper inspection & maintenance	8	6	13	7	8	7
Publics' legal and moral awareness	9	2	6	14	13	5
Weak ability to identify & monitor the threats	10	10	11	6	11	14
Stakeholders are not paying proper attention	11	8	5	15	15	16
Lack of proper training	12	9	10	13	19	6
Exposed pipelines	13	16	21	8	5	19
Shortage of the IT services & modern equipment	14	12	17	12	17	15
Limited warning signs	15	20	16	18	6	18
The pipeline is easy to access	16	17	19	5	18	17
Lack of risk registration	17	18	14	19	14	12
Little researches on this topic	18	19	12	20	23	13
Design, construction & material defects	19	23	22	17	12	10
Conflicts over land ownership	20	14	18	11	16	26
Threats to staff	21	22	15	22	20	22
The education and poverty levels in OGPs areas	22	13	20	21	25	24
Operational errors	23	24	23	23	21	21
Inadequate risk management	24	21	25	24	22	20
Leakage of sensitive information	25	25	24	25	24	23
Geological risks	26	26	26	26	26	25
Natural disasters & weather conditions	27	27	27	27	27	27
Vehicles accidents	28	28	29	28	28	28
Hacker attacks on the operating or control system	29	29	28	29	29	29
Animals accidents	30	30	30	30	30	30

Table 7. The usability degree of each RMM by participants' occupation.

RMMs	Usability					
	Total	I	II	III	IV	V
Avoid "Insecure-Zones	3.652	2.929	3.789	3.829	3.385	3.758
Anti-terrorism design	3.475	2.643	3.676	3.268	3.564	3.545
Avoid the registered risks and threats	3.616	3.357	3.662	3.634	3.513	3.727
Proper training	3.768	3.643	3.634	3.854	3.769	4.000
Move to an underground pipeline	4.051	3.857	4.085	4.390	3.846	3.879
Anti-corrosion such as isolation and cathodic protection	4.247	4.000	4.282	4.512	4.103	4.121
Protective barriers and perimeter fencing	3.783	3.214	3.732	3.878	3.872	3.909
Warning signs and marker tape above the pipeline	3.727	3.143	3.732	3.683	3.846	3.879
Foot and vehicles patrols	3.606	3.143	3.648	3.683	3.590	3.636
High technology and professional remote monitoring	3.480	2.643	3.606	3.415	3.359	3.788
Government-public cooperation	3.278	3.000	3.183	3.463	3.205	3.455
Proper inspection, tests and maintenance	3.677	3.429	3.549	3.805	3.769	3.788

Table 8. The effectiveness degree of each RMM by participants' occupation.

RMMs	Effectiveness					
	Total	I	II	III	IV	V
Anti-corrosion such as isolation & cathodic protection	4.232	3.857	4.113	4.415	4.513	4.091
Move to an underground pipeline	4.066	3.929	4.000	4.220	4.333	3.758
High technology & professional remote monitoring	3.995	3.643	4.070	3.878	4.000	4.121
Proper inspection, tests & maintenance	3.828	3.429	3.887	3.829	3.872	3.818
Proper training	3.793	3.857	3.662	3.780	3.897	3.939
Avoid "Hot-Zones	3.778	3.214	4.014	3.659	3.744	3.697
Anti-terrorism design	3.778	3.143	3.986	3.341	4.179	3.667
Avoid the registered risks & threats	3.773	3.500	3.817	3.683	4.000	3.636
Protective barriers & perimeter fencing	3.682	3.214	3.577	3.756	3.872	3.788
Warning signs & marker tape above the pipeline	3.571	2.929	3.577	3.439	3.923	3.576
Government-public cooperation	3.545	3.214	3.563	3.561	3.564	3.606
Foot & vehicles patrols	3.530	3.429	3.563	3.634	3.615	3.273

5. Discussion

By using the RI to rank the RFs, the overall results of the survey show that the terrorism and sabotage, corruption, insecure areas, lawlessness and thefts are the most critical RFs in OGPs projects in Iraq. Nevertheless, the ranking of the RFs is quite varied deepening on the occupations of the stakeholders. Regarding the planners, consultants and designers perceptions corruption, low public legal and moral awareness, sabotage actions, lawlessness and improper safety regulations are the top five RFs that influence the pipeline projects. The stakeholders who are working in the construction filed have ranked the top five of RFs as follows. Terrorism and sabotage actions, corruption, lawlessness, corrosion and lack protection against it, thefts and the stakeholders are not paying proper attention. The operators have come with different ranking as follows. Terrorism and sabotage actions, insecure areas, corruption, thefts, and the pipelines are easy to access. The projects' owners and clients have said that the terrorism and sabotage actions, corruption, lawlessness, corrosion and lack protection against it, and the exposed "aboveground" pipelines are the top five RFs. The participants from the academic field indicated that corruption, terrorism and sabotage actions, corrosion and lack protection against it, insecure areas and low public legal and moral awareness the most critical RFs.

Regarding evaluating the RMMs by their degree of usability, the overall results of the survey indicate anti-corrosion such as isolation and cathodic protection, move to an underground pipeline and protective barriers and perimeter fencing are the RMMs with the higher chance of usability in OGP projects in Iraq. The planners, consultants and designers have another point of view, which is anti-corrosion such as isolation and cathodic protection, move to an underground pipeline, and proper training are the mitigation methods with the higher rate of usability. Anti-corrosion such as isolation and cathodic protection, move to an underground pipeline and avoid "Insecure-Zones" are the more useable methods as construction said. The operators came with a different observation that is like this anti-corrosion such as isolation and cathodic protection, move to an underground pipeline and protective barriers and perimeter fencing are the most useable methods. Which slightly different for the owners and clients observations that are as follows: the methods of the higher rate of usability are anti-corrosion such as isolation and cathodic protection, protective barriers and perimeter fencing and move to an underground pipeline. The researchers said that the anti-corrosion such as isolation and cathodic protection, proper training and protective barriers and perimeter fencing are the most usable risk mitigation methods.

The result of evaluating the effectiveness of the RMMs are anti-corrosion such as isolation and cathodic protection, move to an underground pipeline and high technology and professional remote monitoring are the most effective RMMs. However, move to an underground pipeline, anti-corrosion such as isolation and cathodic protection and proper training are the most effective RMMs as the consultants, planners and designers said. Which is different from the observation of the construction teams that are as follows. Anti-corrosion such as isolation and cathodic protection, high technology and professional remote monitoring and avoid "Insecure-Zones are the most effective RMMs. The opinion of the operators is like that anti-corrosion such as isolation and cathodic protection, move to an underground pipeline and high technology and professional remote monitoring are the most effective RMMs. Which is different from the opinions of the owners and clients as they said anti-corrosion such as isolation and cathodic protection, move to an underground pipeline and anti-terrorism design are the most effective RMMs. The researchers think like that high technology and professional remote monitoring, anti-corrosion such as isolation and cathodic protection and proper training are the most effective RMMs.

The survey results were found to be reliable as all Cronbach's alpha coefficient factor values are above 0.7, as explained in Table 2. Collecting the required information from various and trusted sources such as research articles and stakeholders provides real information for OGPs risk management. However, it depends on the availability of such documents and the willingness of the stakeholders to cooperate with the authors. Analyzing the RFs and evaluating the RMMs based on the perceptions of the stakeholders could reduce the time and the cost of the investigations and increase the stakeholders' awareness about their responsibilities regarding OGPs risk management. As well as, it helps to analyze OGPs RFs more realistically and to identify the positive and negative recommendations about RMMs in a way that ensure the continuity of pipeline security. Because the perceptions of the stakeholders are based on real experience about OGPs issues. Furthermore, correct sampling and representing the whole stakeholders' categories enhances the results of RFs analysis and RMMs evaluation.

6. Conclusion

There is a need for an accurate analysis of OGPs RFs because the external RFs have not been accurately analyzed yet. The overall results of the survey showed that the external risk factors like terrorism and sabotage, corruption,

insecure areas, lawlessness and thieves were found the most critical risks in OOPs projects in Iraq. Avoid "Insecure-Zones, anti-terrorism design and avoid the registered risks and threats were found as the most usable risk mitigation methods. Meanwhile, anti-corrosion such as isolation & cathodic protection, move to an underground pipeline and high technology & professional remote monitoring were the most effective risk mitigation methods. While, regarding their occupations in OGPs, the stakeholders in OGPs have different perceptions about this ranking.

This paper provided verified information about risk factor and risk mitigation methods such identifying the risk factors, analyzing the factors' "probability and severity" and evaluating the "usability and the effectiveness" of the risk mitigation methods. Such information could the help organizations and countries that just began to mitigate OGPs risk factors more effectively and to provide useful recommendations for their actions and plans about OGPs risk management in the insecure countries such as Iraq.

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