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International Journal of Current Research
Vol. 10, Issue, 04, pp.67918-67923, April, 2018

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

RISK ASSESSMENT APPLICATION THROUGH FMEA TECHNIQUE IN THE SCOPE OF OHS MANAGEMENT SYSTEM IN FORESTRY SECTOR (NON-WOOD FOREST PRODUCTS SAMPLE)

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ARTICLE INFO

Article History:
Received 14th January, 2018
Received in revised form
21st February, 2018
Accepted 27th March, 2018
Published online 30th April, 2018

Key words:
FMEA,
OHS,
Non-Wood Forest Product, Forestry,
Risk,
Risk Assessment, RPN.

ABSTRACT

With the development of industrialization over time, occupational accidents and diseases have appeared more than ever and the subjects "providing occupational health and security" and "their constant improvements" have gained importance. One of the working areas having serious risks in terms of occupational health and security is the forestry sector involving the facilities which process the non-wood forest products. Various methods exist for risk assessment and FMEA (Failure Mode and Effects Analysis) is one of these assessments. The core idea of FMEA is to prevent failures and risks before they appear instead of detecting them afterwards. Also, unlike other risk assessments, prior detection of accidents in this one is a distinctive advantage. In this study, the failure types, the potential reasons for them and their possible effects were determined through FMEA analysis in an enterprise that process non-wood forest products (bay leaves) and Risk Priority Number (RPN) acquired by multiplying the severity, probability and detectability values of failure type was calculated and the necessary measures were taken according to the values in the order of priority. Then, the required improvement activities were made by determining the proposed measures to be taken against the risks and the pre and post application values were compared by revealing the changes in RPN values. In summary, this study leads to a significant progress for assuring a system security at the enterprise.

Citation: Tuna EMİR, Tuğrul VAROL, Halil Barış ÖZEL and Selda ERGİN, 2018. "Risk assessment application through fmea technique in the scope of ohs management system in forestry sector (non-wood forest products sample)", *International Journal of Current Research*, 10, (03), 67918-67923.

INTRODUCTION

What is implied with the risk assessment is to determine the measures to be taken by pre-determining the possible harms to the employees, the workplaces and environmental damages by the risks existing in the workplace or possible ones (Tezel, 2004). Risk assessment activities provide benefits to the employer in many cases such as identifying the risks, pre-determining them, establishing secure environment for the employees, reducing the losses by avoiding accidents, increasing the quality and productivity, prestige, proactive approach, readiness for emergency and task sharing (URL-1, 2016). There are different application methods of risk assessment and there is no consensus which one would be the most convenient. Therefore, risk assessment teams have to pick the most suitable one for their own groups. On the other hand, it will not be a scientific approach to apply the same method to any type or scale of enterprise (Yılmaz, 2010).

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Which risk assessment approach should be used depends on such several factors as the content and course of work, technical complexity and the features of activities (Müller, 2008). At this point, FMEA (Failure Mode and Effects Analysis), which can be used in each sector, is a systematic method that aims to detect failures in advance, prevent the system problems from arising vigilantly and evaluate the probable reasons of failures rather than detect the failures afterwards and fix them (failure management). While FMEA was commonly used in the manufacturing sector, especially in automotive sector, as a primary estimation technique in the past (Elliott, 1998), it has come into use lately in all sectors for the purpose of preventing failures (Çevik and Aran, 1999). Unlike the conventional risk assessment, the integration of "detectability" factor makes a significant difference (Akın et al., 1998). FMEA finds solutions by handling firstly the failure types that could best contribute to the overall system instead of improving all the hundreds of failure types (Kahraman and Demirer, 2010). The first step in analyzing the failures through FMEA is to identify these failures.

Later, it is aimed to estimate their effects and determine their priorities and detections. They are handled in a particular system and formula. There are three main factors in determining the priorities for failures.

- Probability of Occurrence (S_f)
- Severity (S)
- Detectability (S_d) (Wang et al., 2009)

$RPN = S_f \times S \times S_d$ (Equity 1).

These factors are the degrees of difficulty in finding out the following reasons: occurrence for the failure frequency, severity for the effects of failure and detection for situations causing damages. RPN is numerical value that is determined based on these three factors (Equity 1). Because the risks for each failure type are identified with RPN, starting from the one of highest RPN, the required corrective measures are determined to minimize it in the short term and abolish it in the long term (Yılmaz, 1997).

The majority of bio-diversity that the forests in Turkey covering 27,2% of the total acreage of the country (21,2 million ha) are constituted by non-wood forest products [SPO, 2006]. NWFP is defined as any kind of herbal and animal products in glades and in-forest areas that human beings and other living creatures make use of in order to meet their needs or earning income [SPO, 2001]. According to World Health Organization (WHO), the number of plants for multipurpose uses is around 20.000. 10% of these plants are merchandized. In Turkey, the number of this kind of plants, collected from the nature, is 346 and 98 of these are exported [Sarı and Oğuz, 2000]. The content of NWFP can be exemplified as wild food plants, medical plants, aromatic plants, dyestuff vegetables, bulbous plants, fungus, and honey.

These are

- Wood, crust, fruit, flower and their leaves besides the environmental functions of the species such as peanut pine, linden, walnut, oak, chestnut, hazelnut, cranberry, hawthorn, almond, acacia, juniper, eucalyptus, rhododendron, locust, bay tree, laurel,
- Flowers, leaves and bulbs of plants such as orchid, yoghurt flower, orchid, white lily, chalk plant, sage, thyme, black currant, snowdrop, bee balm, belladonna, orchard, crown imperial, hyacinth, gerber,
- Fruit and flowers of plants such as blackberry and hip
- Edible natural fungi
- Plants like lichen, algae and bulrush

Bay leaf is also used in defense industry as the raw material of gunpowder as well as mainly in medicine, cosmetics, sanitation and healthcare sectors. 80% of the bay leaf that Europe needs is met from Turkey. Despite many risk assessments which consider the existing risks and dangers especially in manufacturing process in forestry sector in Turkey, the analyses for risks and dangers of non-wood forest products are insufficient. The aim of this study was to identify the failure types through FMEA approach in the scope of risk assessment to be made in an enterprise which process non-wood forest products (bay leaf) grown in forests, the potential reasons for these types and probable effects and to provide a system approach for preventing a cautious figure before the failures occur.

MATERIALS AND METHODS

This study was carried out in an enterprise which process non-wood forest products (bay leaf) and employ about 50 employees, mostly females, in a year. The plant raw material collected from the nature as fresh is firstly dried in the ovens and then subjected to a milling process involving whisking and removing the spoils. With FMEA, it is aimed to prevent the accident in some way by predicting the probable circumstances that could cause occupational accidents through RPN values after processing all the failure types through severity, probability and detection (Table 1-2-3-4) in this enterprise. FMEA carried out in the enterprise is comprised of the following steps (Figure 1):

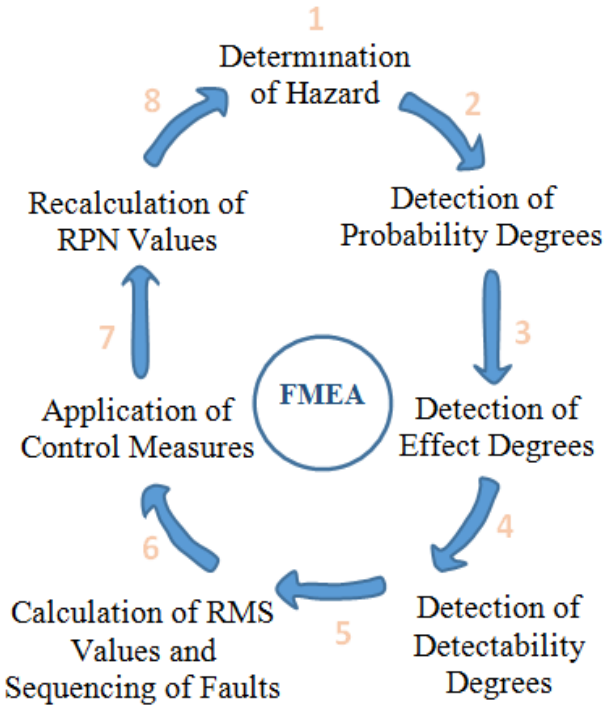

Figure 1. Analysis Steps of Error Type and Impact

Table1. Traditional FMEA Scale for Severity (S) (Pillay and Wang, 2003)

SEVERITY	RATING
Remote	1
Low	2
	3
Moderate	4
	5
	6
High	7
	8
Very High	9
	10

Risk priority number enables to determine for which failures we need to take primary measures sorting by priority. Starting with the RPN which is of the highest value, it is checked whether or not control measures are taken in order to reduce this value and then the corrective measures are presented in the risk assessment tables according to the existent/non-existent measures. The criteria used in RPN evaluation are given in Table 5 and Figure 2.

RESULTS

The enterprise is a facility where the milling and drying is made in order to integrate the non-wood forest products (bay leaf) into economy. About 50 employees, most of whom are females, work in this enterprise. Before the risk assessment through FMEA, the employees were given both theoretical and sampling information training in the subject areas of risk perception, assessment and evaluation.

According to the subject of the activity in the enterprise, the working area was paid a formal visit with B and C class occupational safety specialists and the working conditions were examined and the risks in the enterprise were determined. As a result of this field work, an evaluation meeting was held and the probable risks out of routine and the ones determined by all the team members were detected together. In this way, it was aimed to produce the solutions to the failure types that could best contribute to the overall system instead of the improvement of all of the tens of failure types.

Table 2. Traditional FMEA Scale for Probability of Occurrence (S_f) Table (Pillay and Wang, 2003)

PROBABILITY OF OCCURRENCE	POSSIBLE FAILURE RATE (OPERATING DAYS)	RATING
Very High: Inevitable Error	1:2	10
	1:10	9
High: Repeatedly Error	1:20	8
	1:100	7
Moderate: Occasional Error	1:200	6
	1:1000	5
Low: Comparatively Less to Error	1:2000	4
	1:10000	3
Remote: Non-Probability Error	1:20000	2
	< 1:20000	1

Table 3. Traditional FMEA Scale for Detectability (Sd) Table (Pillay and Wang, 2003)

DETECTABILITY	RATING	PROBABİLİTY OF DETECTİON (%)
Remote	1	86-100
Low	2	76-85
	3	66-75
Moderate	4	56-65
	5	46-55
	6	36-45
High	7	26-35
	8	16-25
Very High	9	6-15
	10	0-5

Table 4. Interpretations of the Linguistic Terms (Pillay and Wang, 2003)

Linguistic term	Probability of occurrence	Severity	Detectability
Remote	It would be very unlikely for these failures to be observed even once	A failure that has no effect on the system performance, the operator probably will not notice	Defect remains undetected until the system performance degrades to the extent that the task will not be completed
Low	Likely to occur once, but unlikely to occur more frequently	A failure that would cause slight annoyance to the operator, but that would cause no deterioration to the system	Defect remains undetected until system performance is severely reduced
Moderate	Likely to occur more than once	A failure that would cause a high degree of operator dissatisfaction or that causes noticeable but slight deterioration in system performance	Defect remains undetected until system performance is affected
High	Near certain to occur at least once	A failure that causes significant deterioration in system performance and/or leads to minor injuries	Defect remains undetected until inspection or test is carried out
Very high	Near certain to occur several times	A failure that would seriously affect the ability to complete the task or cause damage, serious injury or death	Failure remains undetected, such a defect would almost certainly be detected during inspection or test

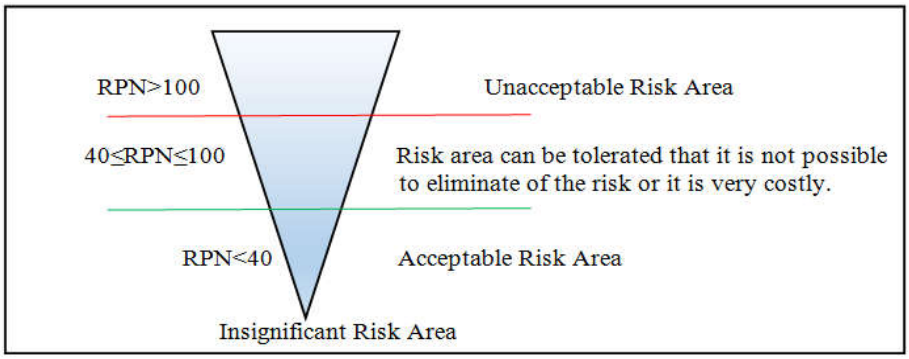

Figure 2. Determination of Risk Zones According to RPN Values (URL-2)

Table 5. Risk Priority Number (RPN) Evaluation Table (Kahraman and Demirer, 2010); (URL-2, 2018)

RPN VALUE	PRECAUTİON
RPN<40	There is no need to take precautions
40≤RPN≤100	The precaution can be taken
RPN>100	The precaution are required

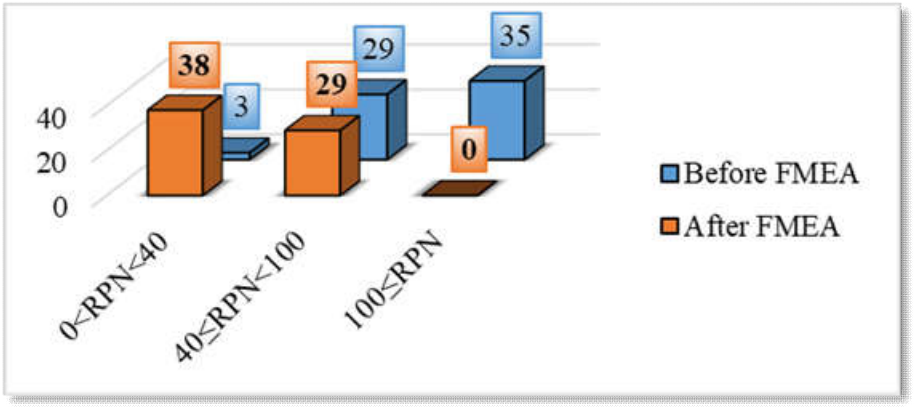

Figure 3. Grouping of Risk Factors by Precaution Level Before and After FMEA

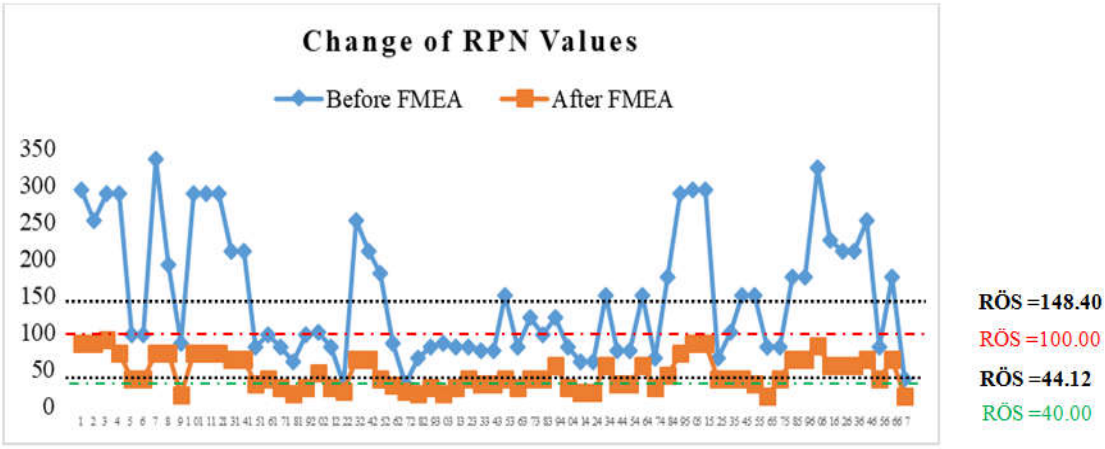

Figure 4. Change of RPN Values before and after FMEA

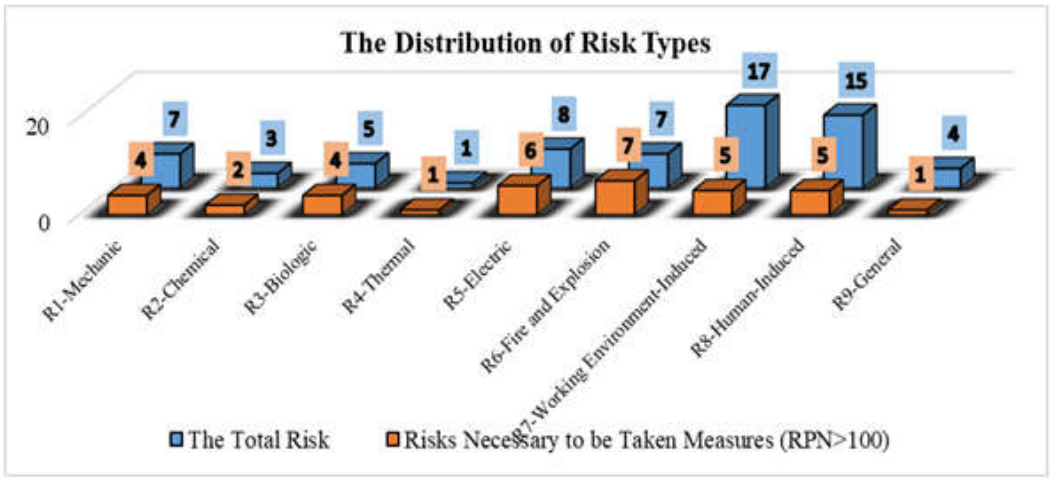

Figure 5. The Distribution of Risk Types in the Enterpris

Table 6. Risk Factors with the Greatest RPN Values (T5-T6) and the Measures to be Taken

Fault Code	The Type of Fault	Previous				Measure To Be Taken	Next			
		S_f	S	S_d	RPN		S_f	S	S_d	RPN
R5	The lack of periodical control certificate of electrical installation	6	8	6	288	All electrical installations must be checked regularly by authorized personnel every year and it must be subjected to maintenance.	3	8	3	90
R5	The lack of the leakage current relay	7	7	6	294	Each distribution panel in the electrical panel must have a separate leakage current relay.	3	7	4	84
R5	Inadequate condition of electricity distribution panels	6	8	6	288	Faults must be rectified by a qualified electrician and appropriate KKD should be provided. Insulated mats should be placed under the panels and the panels must be locked.	3	8	3	72
R5	The lack of body grounding	6	7	6	252	Alternating or direct current powered electrical equipments must be grounded appropriately.	3	7	4	84
R5	Being of open sockets	4	6	4	96	Open sockets should be closed.	3	6	2	36
R5	Status of electrical panels	6	8	6	288	Appropriate warnings must be hung on all electrical panels, the front of it should be left blank and insulated mats should be placed under the panels. There should be no flammable material around the panels.	4	8	3	72
R5	The fuses do not have proper isolation.	5	6	5	150	Proper insulation of the fuses should be made, it protective covers must be installed and kept closed.	3	6	2	36
R5	Status of extension cables	5	4	4	80	The use of extension cables should be avoided, the cables must be inserted into the channel.	3	4	2	24
R6	Lack of fire fighting equipment	6	8	6	288	Places where fire fighting equipment is located shall be marked with a red sign. Fire crews will be set up and all employees will be informed about the crews.	3	8	3	72
R6	The absence of cleaning the chimney and ventilation	5	7	5	175	Regular maintenance and cleaning of chimneys and ventilations should be done.	3	7	3	63
R6	The lack of fire precautions	5	7	5	175	An appropriate number and type of fire extinguisher must be available at the workplace. Related training and operations should to be performed.	3	7	2	42
R6	Non-wood forest product (leaf)	7	7	6	294	Warnings should be found indicating that the non-wood forest product is a flammable substance, employees and visitors should be warned about it.	4	7	3	84
R6	Use of boiler and coal	6	9	6	324	Periodic tests should be performed once a year, deficiencies must be corrected urgently. The staff member must be certified. There should be a system that gives sound and light warning at high pressure. The stacking height of coal bags should not exceed 3 m.	3	9	3	81
R6	Heaters	5	6	5	150	The heaters should be kept away from the substances that can easily be burned, there should be systems that automatically cut off the electricity when it is overturned.	3	6	3	54
R6	Absence of lightning rod	4	8	6	192	The control of the lightning arrester must be done once a year by authorized persons and all relevant data must be written to the measurement results.	3	8	3	72

FMEA activity was conducted in the enterprise in 12 months. As a result of risk assessment, a total of 67 risk factors were detected. These detected risk factors were grouped by taking into account the measure levels, according to Pillay and Wang (2003), the improvement suggestions were made by prioritizing a total of the required 100≤RPN 35 risk factors that take place in the unacceptable risk area and must necessarily be taken measures primarily (Figure 3). Moreover, the corrective measures in order to reduce the critical RPN values were taken and the protection of the improvements was provided. The average of RPN, which was 148.40 before FMEA, was reduced to 44.12 after this study (Figure 4).

As can be understood from Figure 4, no risk case that can cause the shut-down in the enterprise was detected starting with the principle "the work should not be initiated until the specified risk is reduced to an acceptable level" in case of RPN> 400. The distribution of risk factors detected in the enterprise and the number of risk factors (RPN>100) that must be taken measures in any risk types are given Figure 5. When considering the number of risks in the enterprise, we can see that working environment and human-induced risk factors are high in number. 35 risk factors that must be taken measures (100≤RPN), the ones which are of the highest RPN values are fire and explosion when the greatness of RPN values (T6) is considered. 7 risk factors were detected in the enterprise that must be taken measures.

For the risk factors in the enterprise that comes in the second place (T5), 6 factors were detected to take measures and the improvement activities were made (Table 6).

DISCUSSION AND CONCLUSION

It was aimed with this study to find solutions the greatest failure types primarily instead of making improvements for the overall system by using FMEA approach in an enterprise. It was also tried to remove the failure risks through the corrective activities by taking into consideration the probability of failure occurrences. A total of 67 risk factors were detected as a result of the risk assessment. These risk factors were grouped according to the levels of measure and the improvement suggestions were made by prioritizing a total of 35 risk factors primarily (100≤RPN) that take place in the risk area and must be taken measures. With this study, the RPN mean rate was 148.40 before FMEA application and it was reduced to 44.12 after the improvement suggestions. When the number of risks were considered in the enterprise, the working environment and human induced risk factors were high number, but the risk factors having the greatest RPN value were fire and explosion when the greatness of RPN values were taken into consideration. What is important is that it was an enterprise where the non-wood forest products are dried (processed). Related to these, 7 risk factors were detected and all of them were considered to be in a status that must be taken immediate measures and the improvement suggestions were made.

The second risk factors involving serious risks are electrical risks. About these, 8 risk factors were detected and 6 of them were considered to be cases that require immediate action and suggestions were made for improvement. In this way, out of 9 risk types, the improvements were made for 35 risk factors that require immediate action before FMEA. All these risk factors were reduced to a tolerable, acceptable level and the safety for the enterprise and employees were provided.

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