Austin Environmental Sciences

Open Access

Austin Publishing Group

Review Article

A Review on the Effects of Rice Straw Burning on the Rice Paddy Fields, Guilan Province Iran

Mohammadi Galangash M[1], Ghasemi Zolpirani R[1], Askari Tappeh F[2] and Forouhar Vajargah M[3]*

[1]Department of Environmental Sciences and Engineering, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Iran

[2]Natural Sciences and Engineering, Faculty of Natural Resources, University of Guilan, Iran

[3]Department of Fisheries, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Iran

***Corresponding author:** Mohammad Forouhar Vajargah, Department of Fisheries, Faculty of Natural Resources, University of Guilan, Sowmeh Sara, Iran

Received: December 20, 2021; **Accepted:** January 12, 2022; **Published:** January 19, 2022

Abstract

Agriculture, as the oldest activity in the world, has positive and negative effects on the environment. In agricultural activities, the main target is to obtain a food product that can be consumed in human nutrition or to produce raw materials for industry. Humans cannot consume some of the plant organs produced, but their existence is not avoidable. Occupancy of Fields by post-harvest crop residues has often become a major problem for farmers. As a result, they burn the crop residue. Burning is one of the most commonly used methods for removing crop residue including rice straw. Guilan province is one of the most important rice productions center in Iran. In this province, farmer's burn straw every year between August to November after harvesting rice, this causes extremely air pollution, violent respiratory problems and damage to the paddy fields soil. Straw burning cause reduces microorganisms in the surface layer of soil, loss of minerals, reduces soil permeability and increases its specific gravity. In fact, despite the awareness about the dangers of rice straw burning in paddy fields, based on a misconception, farmers continue to burn. The effects of this action can be seen in the long-time.

Keywords: Soil properties; Rice straw; Paddy field; Open burning; Crop residue

Introduction

In agriculture, burning crop residues is an activity that is done with various purposes such as converting forestlands to agriculture and changing crops, controlling pests and diseases, removing crop residues after harvest and ease of harvest. In fact, post-harvest incineration has become an important management mode [1]. Most farmers burn the residue immediately after harvest. This makes the soil easier to prepare for the next crop and releases amounts of minerals such as calcium, magnesium, phosphorus and potassium from the residue. On the other hand, burning reduces soil organic matter and reduces soil organic matter in the long-term, leading to losses of nitrogen, carbon, sulfur and other important soil elements through their sublimation.

Annually in Iran, more farmers burning crop residues due to the pest control. This method of crop residue management causes the rapid release of nutrients in the soil and the relative control of pests and weeds. As well as, increases efficiency and is economically and temporarily cost-effective. However, due to destructive effects such as increased erosion, reduced organic matter, biological deterioration, structural and permeability disorders, disturbance of the balance and population of soil microorganisms, besides environmental pollution, ultimately in long-term leads to reduced crop yields [2].

Rice (*Oryza sativa*) is the hugely important food crop for the world's population, especially in East, South, Southeast Asia, the Middle East, Latin America, and the West Indies. In many countries, rice accounts for more than 70% of human caloric intake. In Asia, just over 30% of all calories come from rice [3,4]. Rice is one of the most important crops in Iran. The annual production of rice in Iran was more than 2.6 Mt in 2020. Guilan province with 35% share of total rice crop production is among the main rice production areas in Iran. Rice production share of this province was 42% (1.09 Mt) in 2020 [5].

This article reviews the survey on soil properties changes due to rice straw residues burning. One of the most important crop residues in the Iranian agricultural system is rice straw. Rice straw is a source of soil nutrients and organic materials. Decomposition releases these resources to build and maintain the soil. Soil resources, in turn, enhance crop production. Although burning returns part of the mineral elements to the soil, most of the organic material and nutritional content of straw is lost upon burning. In addition, large and repeated burning at a specific location can damage the physical and chemical properties of soil layers, especially the surface layer. Unfortunately, more than 700000 ton of rice straw annually, burned by guilanian farmers in the months of August to November each year in the Guilan paddy fields. Some legal measures in Iran for example Waste Management Act (approved in May 9, 2004), Clean Air Act (approved in July 16, 2017), and Soil Protection Act (approved in May 25, 2019) to intercept of rice straw burning in guilan could not successful. However, most farmers still despite the ban regulation prefer the burning method. Therefore, the objective of this study was to survey effects of rice straw burning on paddy fields soil in guilan province, Iran.

Location of Guilan Province

Guilan province with an area of 14711 km^2 is located in the north of Iran on the south of Caspian Sea, within 36° 34′ and 38° 27′ north latitude and 48° 53′ and 50° 34′ east longitude (Figure 1). Guilan has a population of 2.5 million people. This province shares a border with

Citation: Mohammadi Galangash M, Ghasemi Zolpirani R, Askari Tappeh F and Forouhar Vajargah M. A Review on the Effects of Rice Straw Burning on the Rice Paddy Fields, Guilan Province Iran. Austin Environ Sci. 2022; 7(1): 1068.

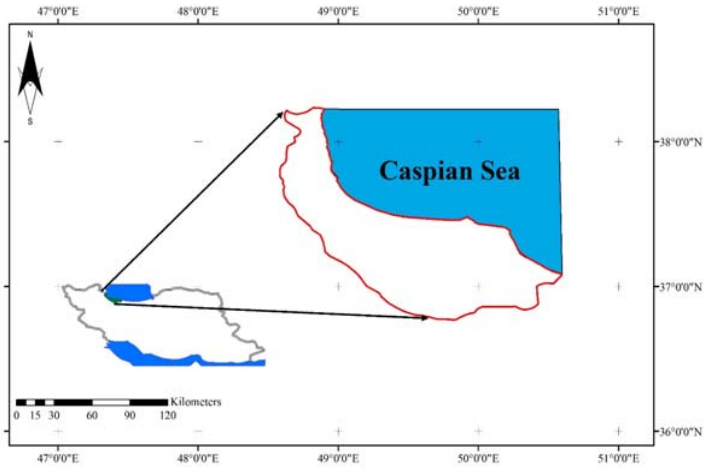

Figure 1: Geographical location of Guilan province.

the country of Azerbaijan. In addition, this province has 300km of coastline [6]. Guilan has a temperate and humid climate. The annual average rainfall of 1100mm and moisture of 80 percent. The average annual temperature is 15.8°C. This province includes the green areas of the northwest of the Alborz mountain range and the western part of the southern shores of the Caspian Sea [7,8].

Rice Cultivated Area in the Guilan Province

Guilan province, with average of 191562.4 hectares of paddy fields and production of about 826105.3 tons of paddy, has a major share in meeting Iran's consumption needs [5,9]. The rice-cultivated area in Iran is approximately 622291 hectares, of which about 35% is located in Guilan province (Figure 2). On average, more than 700000 tons of rice straw (about 3.8 tons of per hectare) is produced from the rice paddy fields of Guilan province (Table 1).

The Effects of Rice Straw Burning on Air Pollution

Rice straw burning cause air pollution

Burning releases a large amount of air pollutants [particular matter (PM), and gases such as sulfur dioxide (SO_2), carbon monoxide (CO), and ammonia (NH_3), ozone precursors including volatile organic carbon (VOC) and oxides of nitrogen (NOx)] and greenhouse gases (CO_2 and CH_4). PM, especially PM2.5 (fine particles with a dynamic diameter less than 2.5lm), can affect human health in a variety of ways: impairing lung function, making breathing more difficult and increasing susceptibility to respiratory diseases [10]. For persons with allergies, smoke in the air can cause annoying symptoms such as sore throat, sore eyes, coughing, nasal and sinus congestion [11,12].

The Effects of Rice Straw Burning on Soil Physicochemical and Biological Properties

According to Le Hoang et al. (2020) study, the rice straw burning helps return essential nutrients such as nitrogen, phosphorus, and potassium to the soil [10]. Despite the rapid increase in some soil nutrients due to the burning of plant residue, most research has shown adverse effects of this method on properties such as organic matter and soil permeability that will hazard the long-term sustainability of

Table 1: Area under cultivation, production paddy and rice straw in Guilan province between 2010 to 2020.

Crop Year	The Amount of Area Under Cultivation (hectares)	The Amount of Paddy Production (ton)	The Amount of Rice Straw Production (ton)
2010-2011	165361	458146	628371
2011-2012	180115	613489	684437
2012-2013	179243	636881	681123
2013-2014	151949	578720	577406
2014-2015	161847	621535	615018
2015-2016	197078	912016	748896
2016-2017	220019	1094860	836072
2017-2018	220000	1093665	836000
2018-2019	220000	1156299	836045
2019-2020	220012	1095442	836045
Average	191562.4	826105.3	727941.3

production in agricultural ecosystems. Aazami and Pourhashemzehi (2018) reported that burning crop residues in the long-term reduces soil fertility, destroys beneficial soil microorganisms, air pollution, and loss of soil nutrients and reduces soil stability [13]. Straw burning process, most of the mineral elements, such as nitrogen, phosphorous, and sulfur, are converted into particulate or volatile matter that diffuses into the atmosphere. Thus, cause wastes these important and necessary nutrient resources in the soil. The remaining phosphorus is insoluble and is difficult for plant to absorb. Almost all of the organic matter into rice straw is lost after burning. High-temperature during burning reduces the organic matter in the soil. Straw burning also reduces soil water content and microorganisms, causing the soil to harden [14]. Huang et al. (2012) reported, after rice straw burning, organic matter and microorganisms decrease in the soil [15]. By reducing organic matter and increasing soil productivity, the soil is significantly compacted, which fills the soil pores and thus greatly reduces the conditions of ventilation and gas exchange, and ultimately soil fertility and activities. So that after

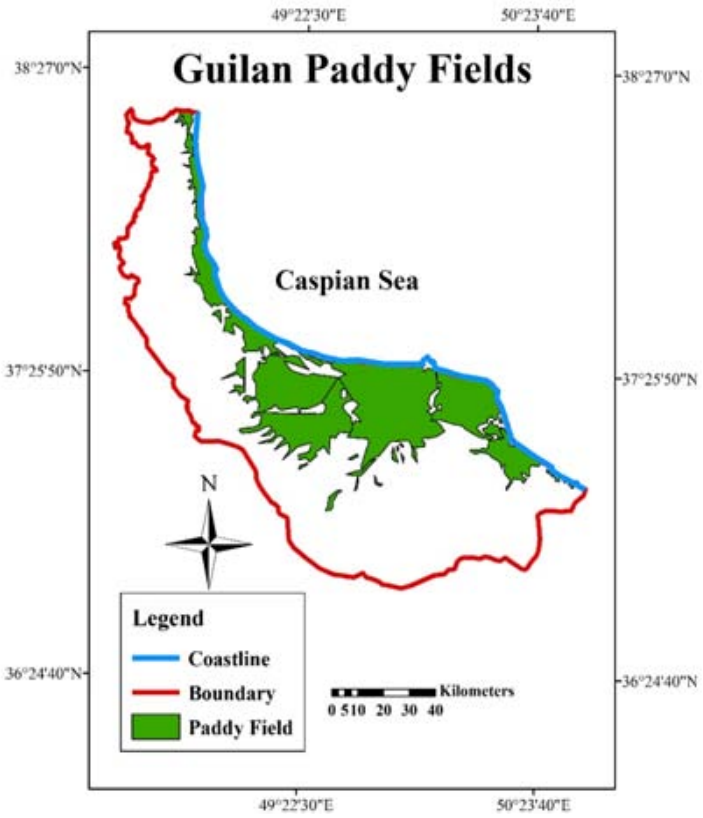

Figure 2: Location of paddy fields in Guilan province.

several periods of farm use when plowing and tillage the soil, large clumps are formed, which indicates a decrease for organic matter [13]? Ash production and the addition of carbon black to the soil resulting from the burning rice straw due to different physical and chemical properties can cause changes in the soil environment. Also results in ash production, which is rich in Ca, Mg and K ions. These contribute cause increases the pH and soluble salts of the soil. High sorption potential due to high specific surface area, having micropore, high porosity and high degree of surface reaction can be considered as the most important properties of black carbon or ash produced by rice straw burning. Soil microorganisms use plant residues as a source of food and energy and the result of their activity in aerobic conditions is the production of carbon dioxide, various mineral and organic compounds. The final decomposition of plant debris produces a complex organic compound called humus [16]. Microbial population of soil is also governed by the factors like soils temperature, pH, moisture content and organic matter. Thus, rice straw burning have an adverse effect on microbial population of soil. After burning of rice straw the surface soil temperature increases to up to 33.8°C-42.2°C. Most of the soil microorganisms are mesophilic having 37°C as their optimum temperature. The sudden increase in temperature during burning results in decline more than 50% of microbial population up to a depth of 2.5cm. However, the effect is temporary, as the microbes regenerate after a few days. However, the effect is temporary, as the microbes regenerate after a few days. These effects become more prominent when burning is practiced continuously for many years. Long-term burning results in lowering of total N and C by 27-73% up to a depth of 1.5cm. Decrease bacterial and fungal populations cause declines organic matter decomposition, which affects aggregate formation and stability [1,17]. Badia and Marti (2003) reported aggregate stability decreases when organic cements were lost to burning because, organic matter is also a critical source of phosphorous, nitrogen, and Sulphur in soil, that loss of them through burning has a great potential to reduce soil fertility to poor levels [18].

The Effects of Preserving Rice Straw on Soil Fertility and Other Utilizations

Crop residues provide a number of environmental services when left in the field, including contributing to the formation of soil organic carbon (SOC), preventing erosion, reducing evaporation from the soil surface, improving soil structure, adjusting soil temperature, supporting living organisms, contributing nutrients to the soil, and providing water filtration and retention capacity [19]. Yaghoubi et al. (2019) reported that rice straw could be used in industrial activities, livestock feeding, and providing fuel [20]. Returning crop residues to the soil will increase the pores and reduce the specific gravity of the soil and, consequently, increase the water storage capacity and air exchange in the soil. Rice straw can absorb the effect of raindrops, reduce the degradation of soil aggregates, reduce splash erosion and consequently reduce runoff and soil loss [21]. Research of Adekalu et al. (2007) showed that straw reduces the evaporation and improvement of aggregates. Ghasemi Zolpirani (2013) reported that rice straw could be used to make pulp and cardboard. In addition, the

use of straw as a raw material for the cultivation of edible mushrooms can improve their quality [22]. Guilan province has 1100000 livestock that straw produced in Guilan paddy fields can provide about 75% of their feed. In this way, by returning straw to the fields, it can increase their soil fertility and provide the nutritional need of live stocks.

Conclusion

According to the main finding of study, agriculture is the most important indicator of economic activity in Guilan province, through which the life of a large part of the people of this province is provided. Guilan province as one of the most important centers of rice production in Iran has always played a very important role in providing this strategic product. Therefore, any action that causes damage to the soil resources of the paddy fields of this province can disrupt the supply of rice required by Iran. Burning rice straw after harvest, although in the short-term does not show its adverse effects, but in the long-time reduces soil fertility by reducing organic matter, eradicate microorganisms and destroying soil minerals. There is still a common thought among farmers with burning straw they increase their crop productivity. This misconception has caused a lot of damage to farmers. Burning crop residues is completely contrary to the goals of achieving sustainable agriculture. Farmers can play an important role in improving the quality of agricultural products by maintaining crop residues and rotation in their crop systems. Efforts to increase farmer's awareness of the benefits of preserving straw in their paddy fields and creating culture in this scope can lead to positive results. Strengthening this approach among farmers will reduce their efforts to burn straw on their farms.

References

1. Najafinezhad H, Rashidi N, Rostami M, Javaheri M. Effects of wheat and canola residues management and tillage methods on maize yield and some soil properties. Seed and Plant Production Journal. 2017; 33: 61-83.
2. Jamali M, Bakhshandeh E, Yaghoubi Khanghahi M, Crecchio C. Metadata Analysis to Evaluate Environmental Impacts of Wheat Residues Burning on Soil Quality in Developing and Developed Countries. Sustainability. 2021; 13: 6356-6369.
3. Röder M, Jamieson C, Thornley P. (Stop) burning for biogas. Enabling positive sustainability trade-offs with business models for biogas from rice straw. Biomass and Bioenergy. 2020; 138: 105598.
4. Mohamadi M, Ghasemi R, Naeimi M. Distribution Pattern of Heavy Metals in Roadside Topsoils around the Rasht-Qazvin Freeway. Journal of Health. 2018; 9: 249-258.
5. Ministry of agriculture-jahad. 2021.
6. Yalsuyi AM, Vajargah MF, Hajimoradloo A, Galangash MM, Prokić MD, Faggio C. Evaluation of behavioral changes and tissue damages in common carp (*Cyprinus carpio*) after exposure to the herbicide glyphosate. Veterinary Sciences. 2021; 8: 218.
7. Mohammadi Galangash M, Ghasemi Zolpirani R, Naimi Joubani M. Evaluation of roadside soils pollution with heavy metals (Pb, Ni, Cu, Zn) in the Rasht-Qazvin old road (Guilan province). Iranian Journal of Health and Environment. 2020; 13: 409-420.
8. Nikkhah A, Emadi B, Firouzi S. Greenhouse gas emissions footprint of agricultural production in Guilan province of Iran. Sustainable Energy Technologies and Assessments. 2015; 12: 10-14.
9. Mohammadi galangash M, Hedayat P, Fazlollahi A. Heavy metals pollution in surface soils of Jamalabad District of Lowshan in Guilan Province. Archives of Hygiene Sciences. 2018; 7: 295-302.
10. Le HA. Emission inventories of rice straw open burning in the Red River Delta of Vietnam: evaluation of the potential of satellite data. Environmental Pollution. 2020; 260: 113972.
11. Ghasemi Zolpirani R. Investigation of air pollutants caused by rice straw burning in farms of Guilan province Proceedings of the First National Conference on Environment, Energy and Biodefense. Iran, Tehran: civilica; 2013.
12. Mohammadi Galangash M, Ebrahimi Sirizi Z. Source Identification and Risk Assessment of Polycyclic Aromatic Hydrocarbons (PAHs) in Coastal Sediment of Caspian Sea; Guilan Province. Journal of Mazandaran University of Medical Sciences. 2017; 27: 128-140.
13. Aazami J, Pourhashemzehi S. The Effect of Arson in Agriculture on the Environment (Case study: Esfahan Province). Human & Environment. 2018; 16: 113-124.
14. Shi T, Liu Y, Zhang L, Hao L, Gao Z. Burning in agricultural landscapes: an emerging natural and human issue in China. Landscape Ecology. 2014; 29: 1785-1798.
15. Huang Z, Hu L, Shi M, Li X. Changes in composition of soil organic matter after burning of straw. Acta Pedologica Sinica. 2012; 49: 60-67.
16. Turmel M-S, Speratti A, Baudron F, Verhulst N, Govaerts B. Crop residue management and soil health: A systems analysis. Agricultural Systems. 2015; 134: 6-16.
17. Chowdhury S, Farrell M, Butler G, Bolan N. Assessing the effect of crop residue removal on soil organic carbon storage and microbial activity in a no-till cropping system. Soil Use and Management. 2015; 31: 450-460.
18. Badía D, Martí C. Plant ash and heat intensity effects on chemical and physical properties of two contrasting soils. Arid Land Research and Management. 2003; 17: 23-41.
19. Searle S, Bitnere K. Review of the impact of crop residue management on soil organic carbon in Europe. The International Council on Clean Transportation, Working Paper. 2017; 15: 1-15.
20. Yaghoubi H, Allahyari MS, Firouzi S, Damalas CA, Marzban S. Identifying sustainable options for rice husk valorization using the analytic hierarchy process. Outlook on Agriculture. 2019; 48: 117-125.
21. Kukal SS, Sarkar M. Splash erosion and infiltration in relation to mulching and polyvinyl alcohol application in semi-arid tropics. Archives of Agronomy and Soil Science. 2010; 56: 697-705.
22. Ghasemi Zolpirani R. Investigation of air pollutants caused by rice straw burning in farms of guilan province: University of Guilan. 2013.