

Evaluation of human health (neurodegenerative) risks in rice cultivation based on heavy metal and pesticide load in water

F. Dökmen^{1*}, Y. Ahi², T. T. Dündar³, İ. Doğan⁴, Z. Vryzas⁵

¹Kocaeli University, Vocational School of İzmit, Department of Crop and Animal Production,
Kocaeli, Türkiye

²Ankara University, Water Management Institute, Ankara, Türkiye

³Bezm-i Alem Vakıf University, Faculty of Medicine, Department of Neurosurgery İstanbul,
Türkiye

⁴Ankara University, Faculty of Medicine, Department of Neurosurgery Ankara, Türkiye

⁵ Democritus University, Department of Agricultural Development, Orestiada, Greece

Abstract

Paddy is cultivated on an area of approximately 162.5 million hectares in the world, and the amount of rice obtained is approximately 497 million tons. The highest yield in paddy can be obtained in temperate climate conditions. Turkey's share in world rice production is approximately 450.00 tons per year. Paddy production is carried out in 31 provinces in Turkey. Heavy metals and pesticide residues are so important for cultivation of paddy. In this study, the effect of heavy metals and pesticides on the rice crop and yield quality, the tolerance mechanisms against heavy metals and pesticides and their effects on human health are discussed. And also, we aim to explanation their effects in water resources on rice cultivation and human health.

Key words: Heavy metal, metallic elements, nervous system, paddy, water quality

Introduction

Paddy is cultivated on an area of approximately 162.5 million hectares in the world, and the amount of rice obtained is approximately 497 million tons. While India ranks first in paddy cultivation areas with 44.2 million hectares, China ranks second in production with 148.5 million tons (Anonymous, 2020 and TEPGE, 2020). In the summer months, which is critical in paddy production in the northern hemisphere, there are increased needs for clean irrigation water. In Asian and African continents, there are area-oriented increases (FAO, 2018). The highest yield in paddy can be obtained in temperate climate conditions. Turkey's share in world rice production is approximately 450.00 tons per year. Although it is above the world average production, 20-25% of the need is imported as production is not enough to meet consumption (Anonymous, 2023).

The pressure on water resources and therefore on safe food supply has increased due to the growing industrialization in parallel with the increase in population and excessive consumption and pollution as a result of these. For this reason, it is urgently necessary to define the effects of pollutants in water resources on food and human health and to develop solutions for their removal.

Heavy metals are metallic elements with relatively high concentrations that can show toxic effects even at low concentrations. They disrupt the movement of intracellular calcium in the central nervous system. Accumulation in brain cells causes neuronal diseases such as Alzheimer's and Parkinson's.

Most heavy metals are substances that scientists call neurotoxins. That is, when they enter our body, they kill nerve and brain cells. The blood brain barrier usually prevents dangerous

compounds from entering our brain, but heavy metals such as mercury can pass through this protective wall. In addition, several other heavy metals, including lead, cadmium and arsenic, have been found to kill brain cells. Exposure to heavy metals has also been found to damage memory. Other studies have clearly shown the negative effect of lead exposure on intelligence.

Since heavy metals are known to kill healthy nerve cells, it has been found that heavy metals negatively affect fine motor skills and cause loss of coordination. (<https://www.agir-metallerim-beyin-uzerine-etkileri>).

Today, the interaction of humans with metals has increased due to the change in production methods used in agriculture, increased use of fertilisers and pesticides, unhealthy storage of solid wastes and wastewater, access to nutrients, exhaust gases of transport vehicles, and changes in the quality of fuels used (Özko1, 1996).

Arsenic, mercury, lead and aluminium are the heavy metals that people may be in frequent contact with due to daily use and environmental pollution.

Heavy metals and pesticide residues have different origin but both can be accumulated in agroecosystems through irrigation with polluted water. Heavy metals and certain pesticide residues negatively affect plant physiology of and through the food chain can affect human health and non -target organism. In this study, the effect of heavy metals and pesticides on the physiology of the rice crop and yield quality, the tolerance mechanisms against heavy metals and pesticides and their effects on human health are discussed. In this regard, a holistic methodology was established.

Materials and methods

Turkey has suitable climatic conditions in terms of paddy production. Paddy production is carried out in 31 provinces in Turkey (Figure 1). Meriç-Ergene River basin of Thrace region is in the first place in production. Although it varies according to years, irrigation water problems pose a great problem for rice producers and become the most important factor limiting rice farming. Insufficient rainfall, especially in winter, can cause shrinkage in paddy cultivation areas. One of the other important reasons is the insufficient supply of clean irrigation water. In the Thrace Region, which has the highest cultivation and productivity in paddy production, it has become impossible to use qualified and clean water resources with the desired irrigation water quality in paddy production due to the intense pollution level of the water resources.

In this study, we aim to develop a methodology based on a literature review to determine the effects of heavy metals and pesticide residues in water resources on rice crops and human health. Many studies reviewed (Bowman *et al.*, 2011; Abedin *et al.*, 2020 and Yerli *et al.*, 2020) include physical, chemical and biological detection of water resources based on irrigation water quality regulations, monitoring the effects of pollutants in water resources on crop production according to food legislation, and also on human health with mouse experiments in medicine and MRI examinations.

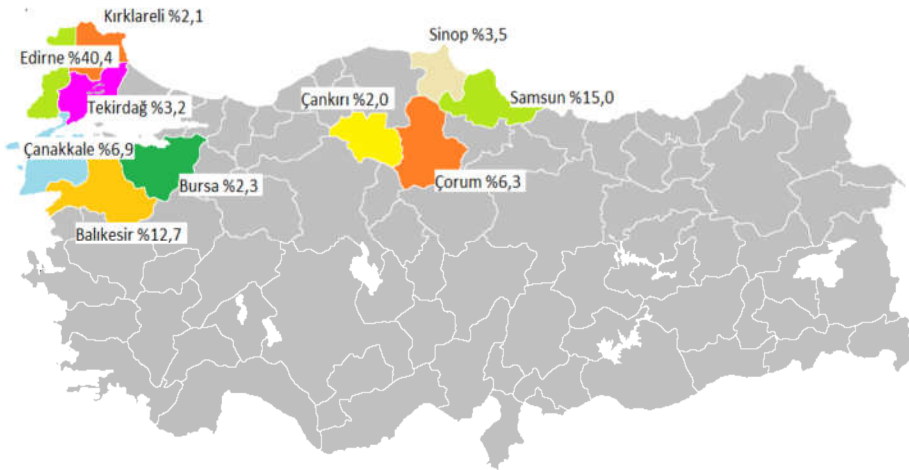


Figure 1. Provinces that are at the forefront of paddy cultivation in Turkey (%)

Results

Environmental pollution caused by heavy metals and pesticide residues can easily reach water resources through runoff, leaching and other processes. As a result, heavy metals and pesticide residues pass from soils to plants and from there to agricultural food production. It can pass into the human body and cause accumulation here.

Since paddy is a plant usually cultivated with border irrigation, water with heavy metal load heavily affects the rice plant, which is exposed to more water during the growing period. Toxic heavy metals such as Cd (cadmium), Cr (chromium), Ni (nickel), Pb (lead), Hg (mercury), Al (aluminum) and As (arsenic), which are found in large amounts in industrial wastewater, and pesticide residues or metabolites of persistent compounds are mainly detected. The long-term persistence of these inorganic factors in their environment creates toxic effects on living organisms and creates risks for human health by accumulating in food

chains. For this reason, the heavy metal bioaccumulation levels in the paddy grown and thus in the rice increase to levels that will adversely affect human health.

Today, heavy metals, which have started to accumulate widely in the soil, water and air of ecosystems, have become an important environmental problem that threatens life. Among the heavy metals reaching the ecosphere, zinc, manganese, cobalt, copper, nickel and molybdenum are absolutely necessary for plant growth, while aluminium, vanadium, arsenic, mercury, lead, cadmium and selenium are toxic. Excessive accumulation of heavy metals in tissues and organs, whether or not they are absolutely necessary elements for plant growth, adversely affects the development of vegetative and generative organs of plants (Gür *et al.*, 2004).

Due to these toxic effects of heavy metals, many physiological events such as transpiration, stomatal movements, water uptake, photosynthesis, enzyme activity, germination, protein synthesis, membrane stability and hormonal balance are disrupted (Kennedy and Gonsalves, 1987).

In order to know the tolerance limits of plants to heavy metal toxicity, the type and amount of metal, its usefulness, the severity and type of damage and the process of damage formation should be taken into consideration. Knowledge of these characteristics is very important for the development and vitality of plants (Paschke *et al.*, 2005).

Accumulation of heavy metals in the soil is not only effective on soil fertility and ecosystem activities, but also affects plant health due to their effect on many metabolic events such as photosynthesis, respiration, growth and development within the plant, and animal and human

health due to the disrupted food chain. As a result of the accumulation of toxic heavy metals in the human body, many health disorders can be seen depending on the type and amount of metal.

None of the toxic substances should be present in the water. In particular, certain amounts of metals known as heavy metals are beneficial for organisms, but the amounts after a certain dose can be harmful to living organisms. Heavy metal pollution is also considered as chemical pollution (Yaşar *et al.*, 2016). Heavy metals can be transported by water and reach marine organisms, soil and humans from there. They can accumulate in high concentrations in soil, water and plants, and can pass to humans through plant and animal foods.

Most heavy metals and insecticides are characterized as neurotoxic compounds that can harm nervous system and cause chronic diseases. Our brain and nervous system control fine motor skills. Since heavy metals are known to kill healthy nerve cells, it is a scientific fact that heavy metals negatively affect fine motor skills. Most of the time, symptoms occur with weakening memory, language skills and thinking skills (Anonymous, 2022).

Conclusion

The relationship between irrigation water quality and heavy metals of the paddy/rice plant, which has an important agricultural production potential in the world and in our country, and, accordingly, important neurodegenerative disorders in human health have been discussed.

References

- Abedin, MJ., Cotter-Howells, J., Meharg, AA. 2020. Arsenic uptake and accumulation in rice (*Oryza sativa* L.) irrigated with contaminated water. *Plant and Soil*. 240(2):311-319.
- Bakar C, Baba A. 2009. Metaller ve İnsan Sağlığı: Yirminci Yüzyıldan Bugüne ve Geleceğe Miras Kalan Çevre Sağlığı Sorunu (Metals and Human Health: The Environmental Health Problem Inherited from the Twentieth Century to the Present and the Future. 1. Tıbbi Jeoloji Çalıştayı.
- Bowman, AB., Kwakye, GF., Hernandez, EH., Aschner, M. 2011. Role of manganese in neurodegenerative diseases. *Journal of Trace Elements in Medicine and Biology*. 25(4):191-203.
- FAO, 2018. Global Information and Early Warning System (GIEWS) (Food Outlook-July), Rome, Italy
- Gür N., Topdemir A., Munzuroğlu Ö ve Çobanoğlu D. 2004. Ağır Metal İyonlarının (Cu, Pb, Hg, Cd) *Clivia* sp. Bitkisi Polenlerinin Çimlenmesi ve Tüp Büyümesi Üzerine Etkileri (Effects of Heavy Metal Ions (Cu, Pb, Hg, Cd) on the Germination and Tube Growth of *Clivia* sp. Pollen Plants. *F.U. Fen ve matematik Bilimleri Dergisi*, 1682), 177-182.
- Kennedy CD, Gonsalves FAN.1987. The Action of Divalent Zinc, Cadmium, Mercury, Copper and Lead on the Trans-Root Potential and Efflux OF Excised Roots, *Journal Experimental Botanic*, 38, 800-817.
- MAF, 2020. Status and Forecast Rice, T.C. Ministry of Agriculture and Forestry Institute of Agricultural Economy and Policy Development, Ankara, Türkiye
- MAF, 2023. T.C. Ministry of Agriculture and Forestry Reports, Ankara, Türkiye
- MH, 2022. T.C. Ministry of Health Reports, Ankara, Türkiye

Özko, S. Metal Kullanımı ve Sağlık Açısından Riskleri (Metal Use and Health Risks. Madencilik Bülteni, 1996; 49:6-7,

Paschke MW, Valdecantos A, Redente EF. 2005. Mamganese Toxicity Thresholds for Restoration Grass Species. Environmental Pollution, 135:313-322.

TEPGE, 2020. Institute of Agricultural Economy and Policies Development Directorate, Agricultural Products Markets Paddy Report, July 2020, Ankara, Türkiye.

Yerli, C., Çakmakçı, T., Şahin, Ü., Tüfenkçi, Ş. 2020. Ağır metallerin toprak, bitki, su ve insan sağlığına etkileri, Türk Doğa ve Fen Dergisi (Turkish Journal of Nature and Science), 9: 103-114.

<https://www.ağır-metallerim-beyin-üzerine-etkileri>