Multidiszciplináris tudományok, 13. kötet. (2023) 1 sz. pp. 295-305 **https://doi.org/10.35925/j.multi.2023.1.21**

ASSESSMENT OF HUMAN SAFETY RISKS FROM THE USE OF PLANT PROTECTION PRODUCTS

Balázs Zákányi
associate professor, University of Miskolc, Faculty of Earth and Environmental Sciences and Engineering
3515 Miskolc, Miskolc-Egyetemváros, e-mail: balazs.zakanyi@uni-miskolc.hu

Flower Delivery Montvajszki
student of Occupational Safety and Health Engineering, University of Miskolc, Faculty of Earth and Environmental Sciences and Engineering
3515 Miskolc, Miskolc-Egyetemváros, e-mail: flower.delivery.montvajszki@student.uni-miskolc.hu

Renáta Zákányiné Mészáros
senior research fellow, University of Miskolc, Research Institute of Applied Earth Sciences, Chamber of Engineers of Borsod-Abaúj-Zemplén County Work Safety Group Chairman
3515 Miskolc, Miskolc-Egyetemváros, e-mail: zakanyine@icloud.com

Abstract

Agriculture is a very serious sector in the life of mankind, with a history that goes back thousands of years, and we know from history that many wars have been fought to gain land in order to obtain better farmland. To meet the needs of growing societies and the increasing pressures that came with it, various technologies were adopted to increase both the quality and quantity of crops. Increasing attention has been paid to the control of crop pests, leading to the emergence of plant protection, which aims not only to kill crop pests but also to produce healthier products for human consumption and to prevent the spread of weeds and their destruction (Ábrahám et al., 2011).

In the course of our work, we have grouped pesticides by active substance. Knowledge of these groups is essential to assess the risks associated with each of these products and, after a detailed risk assessment of the spraying process, to make recommendations for risk reduction to address high unacceptable risks in order to make agricultural work safer for the use of pesticides.

Keywords: *human safety, agriculture, pesticides, spraying risks*

1. Introduction

The world's population has doubled since 1950, but the amount of arable land under cultivation has increased by a very small margin of only 10%. After the Second World War, the chemical industry developed enormously and so did the production of plant protection products, with newer and newer products being developed to protect plants from harmful organisms. However, the methods used in the past have been pushed into the background and intensive chemical control has become the most important method, not only in Hungary but also in Europe. This is also the reason why today crop protection is associated with the use of pesticides (Keszthelyi, 2019).

This is also supported by the chart on pesticide sales published by the KSH, which shows that the amount of pesticides used has increased steadily in the period 2000-2020, Figure 1 shows that since 2000 the use of pesticides has increased 2.5 times, the sales data of the chart is also considered as the use data.

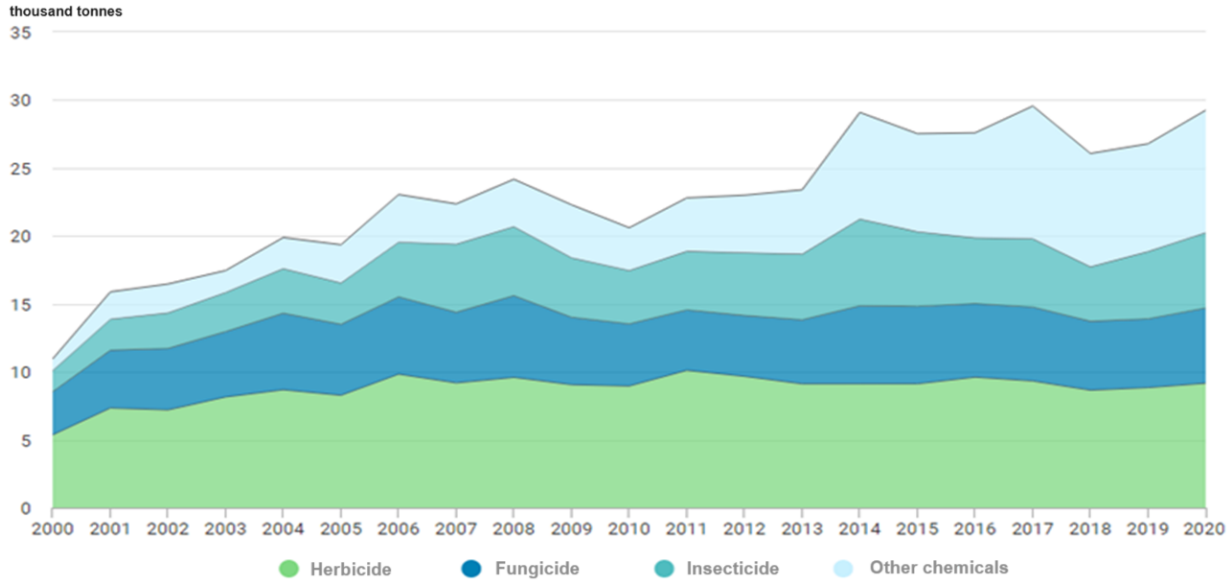

Figure 1. *Quantities of pesticides sold by product group (Source: HCSO, own ed.)*

When we talk about plant protection, we must mention the methods of plant protection used, which is nothing other than a complex method of protection, a set of procedures that can be applied, which can be:

- Agrotechnical protection: based on the respect of cultivation techniques.
- Mechanical protection: these are physical methods used to destroy pests or diseases or to prevent their further growth.
- Biological protection: which is nothing other than an organic production and plant protection system that takes maximum account of environmental conservation.
- Chemical control: preventing the proliferation of pathogens, pests and weeds by using various pesticides, this is what will be discussed in detail in the thesis and the effects on workers will be monitored.
- Integrated pest management: integrated crop management is a form of cultivation where site selection, variety selection, care and crop protection are carried out using as few chemicals as possible (Ms Petes, 2008).

With the focus on protecting human health and the environment, however, the sustainable use of pesticides, also known as pesticides, has become important, allowing pesticide use to be regulated and thereby reducing their harmful effects. Sustainable agriculture, or crop protection, is about meeting the needs of present and future generations, and growing technologies and crop varieties that can produce adequate yields, thus preserving human health but also protecting the environment and preserving its biodiversity (OMMF, 2022).

The essence of integrated farming is that natural and artificial techniques and methods are used in almost equal proportions, i.e. biological and chemical methods are used in harmony with preventive, mechanical, physical and agronomic methods.

The use of chemical treatment is encouraged when no other option is available, or may not be sufficient to control the pest (Algimentes et al., 2020).

2. Grouping of plant protection products

The term pesticide includes any substance or pesticide that is a chemical or biological poison and is capable of killing pests, the main groups being insecticides, herbicides, fungicides, rodenticides, algaecides and other plant protection products (Ábrahám et al, These can cause serious health problems when they enter the body, to prevent these, it is necessary to know the ways in which these products can enter the body, there are several ways, such as through the skin, through the nose (breathing), through the mouth (ingestion of food). They can have a number of adverse effects on the human body, the ways in which they can harm the human body is shown in Figure 2 below.

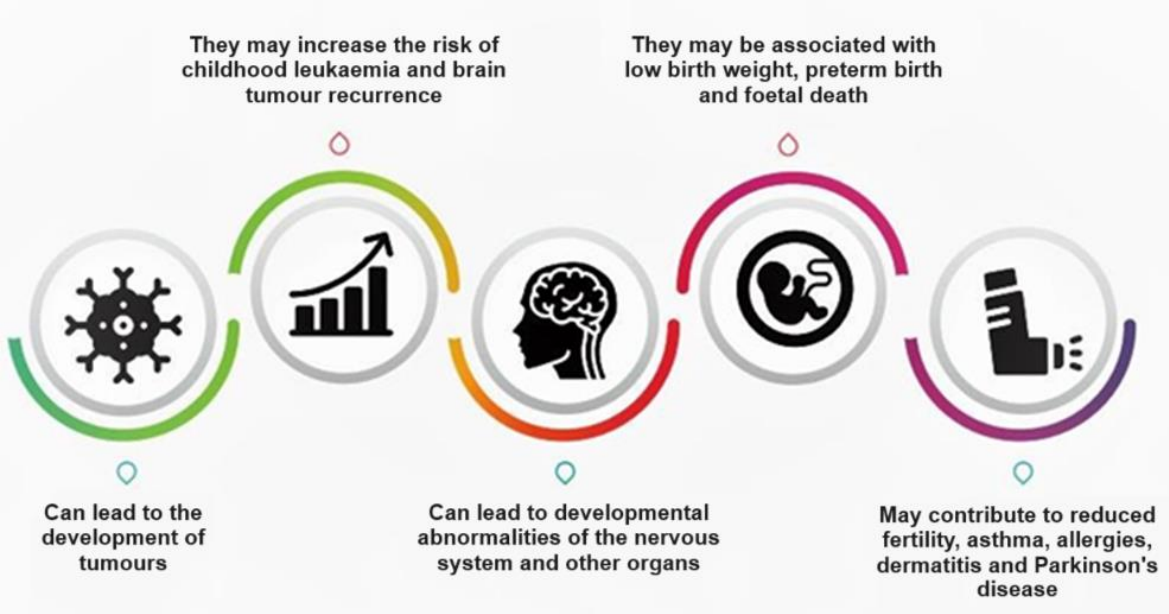

Figure 2. *Harmful effects of pesticides on the body*

In Hungary, currently cca. 700 different plant protection products are on the market, the number of controlled substances is constantly changing, new products are being introduced, existing ones are being modified or withdrawn.

Pesticides are classified in category 3 according to their distribution and use, toxicity and environmental hazard, as mentioned above, taking into account several aspects:

- Category 1 products are only for use by qualified professionals, they are prescription-only products and can only be dispensed by a professional with a specific identification.
- Category 2 may be used by those who have completed an 80-hour course or more in plant protection.
- Category 3 products are those that are free for anyone to buy and use.

There are several ways to group pesticides in this respect, for example when grouping according to the target organism. These groups are listed in the table below (Lorenz, 2009; Keszthelyi, 2019).

Table 1. *Classification of plant protection products (based on Keszthelyi, 2019)*

Plant protection products	Target organisation (area of use)
Insecticides	against insects
Acaricides	against mites and parasites
Nematocides	against nematodes
Rodenticides	against disease-carrying rodents
Limacidek	against snails
Corvicides or avicides	against birds
Piscicidae	against fish
Fungicides	against fungi, bacteria, viruses
Herbicides	against weeds
Plant growth regulators	life process accelerating, slowing down modifying agents
Attractants	pest attractants, attractants
Repellents and repellent agents	pest alarms
Antibiotics	protect plants, animals and people

According to their form or physical characteristics, pesticides can be in liquid or solid form. The solid form, wettable, powder form, spraying, dusting, granulation, water soluble granulation, fumigant.

Liquid formulations are emulsifying spray, water soluble liquid formulation, aqueous suspension.

3. Risk assessment methodology

Risk assessment is a process that involves a careful review of what can harm or endanger workers in a given workplace, and what precautions are needed to avoid or prevent harm to health.

As a first step, we defined the process sequence to be investigated, in this case the pesticide use process, illustrated in Figure 3, based on the pesticide use process presented earlier.

The second step is the preparation of a risk matrix to determine the risks. The risks taken into account are categorised according to two criteria: the probability of the risk occurring and the severity of the consequences of the risk.

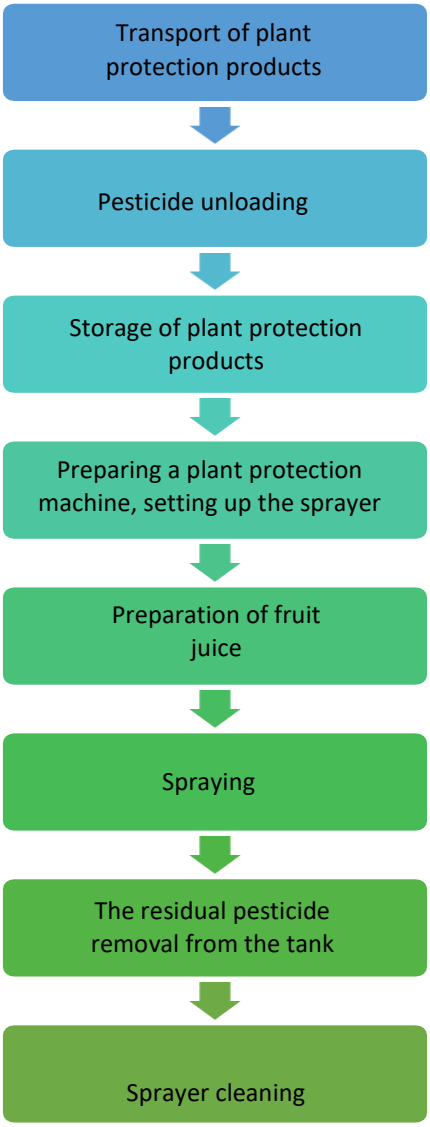

Figure 3. *Flow diagram of pesticide use*

Once the hazards have been identified, it is necessary to consider the severity of the risks, i.e. the likelihood of an event with permanent or fatal consequences.

Table 2. *Risk matrix*

Severity (C) / Probability of occurrence (F)	C1 No personal injury	C2 Minor personal injury	C3 Significant personal injury	C4 Serious personal injury
F1 Unlikely	1	1	1	1
F2 Possible (not unthinkable)	1	2	3	4
F3 Probable	1	3	4	5
F4 Unavoidable	1	4	5	6
Risk assessment (R)= F*C	Risk level	Expected tasks		
RA1-2	Low risk	acceptable risk		
RK3-4	Medium risk	risk reduction is needed		
RM5-6	High Risk	immediate risk reduction is needed		

Values of 1-2 indicate low risk, indicating events with a low probability of occurrence and low personal injury, which is considered an acceptable risk and therefore does not require action.

Values 3-4 indicate a slightly higher probability of accidents with more severe outcomes, and therefore a medium risk where risk reduction is required.

Values 5-6 have the highest probability of occurrence and the most severe consequences. Immediate risk reduction is required.

We give some examples of these from the completed risk assessment.

Table 3. *Example of low risk*

Source of danger→Possible cause→ Conclusion	Classification as a dangerous substance exposure	Risk reduction proposal	Changed risk
improperly secured container overturned container → can be damaged, torn out → the pesticide can enter the storage area, react with other substances, inhalation can cause respiratory can cause illness	F2*C2=RA 1-2 Low Risk	stable fixation, taking into account the properties of the material, the use of personal protective equipment is required, and can be carried out by a person with appropriate knowledge and authorisation	F2*C1=RA 1-2 Low Risk

Table 4. *Example of medium risk*

Source of danger→Possible cause→ Conclusion	Exposure to hazardous substances	Risk reduction proposal	Changed risk
warehouse not properly locked→ unauthorised persons inside, plant protection inappropriate use of products>acut e poisoning	F3*C2=RK3-4 Medium risk	must be lockable and only persons with the appropriate qualifications and authorisations may enter	F2*C2=RA1-2 Low Risk

In the following, we will describe some of the hazards that we have identified as high risk.

Table 5. *Hazard sources with a total high risk score in the risk assessment*

Source of danger→Possible cause→ Conclusion	Exposure to hazardous substances	Risk reduction proposal	Changed risk
materials with each other contact with→storage with other materials→a mixture liable to catch fire or explode, toxic health effects, respiratory diseases, development of tumours,	F3*C4=RM5-6 High risk	must not be stored with feed or food, storage must be in accordance with the instructions on the safety data sheet,	F3*C3=RK3-4 Medium risk
high concentration of particulate matter and gas mixture→ reactive substances reacting with each other stepping on toxic, gases, vapours, dusts	F4*C3=RM5-6 High risk	airspace analysis, access to the warehouse only in protective equipment, minimum number of workers	F4*C2=RK3-4 Medium risk
can be produced, which can cause higher concentrations than permitted el→acut poisoning, cancer, respiratory illnesses, drowning		inside, who have the necessary licence	

Source of danger→Possible cause→ Conclusion	Exposure to hazardous substances	Risk reduction proposal	Changed risk
very toxic, working with toxic substances→ working in groups, bad work organisation→ health problems, organ problems, can cause organ system diseases	F3*C4=RM5-6 High risk	designate a driver and a person who is skilled in first aid and is aware of the following measures, take extra care when carrying out work, be aware of working with toxic highly toxic substances, use personal protective equipment for the licensed use of the substance according to its articles of association	F3*C3=RK3-4 Medium risk
Mechanical hazards, moving parts (propeller shaft) → lack of fender → indent, catching	F3*C4=RM5-6 High risk	the cardan shaft must be fitted with a protective cover	F3*C3=RK3-4 Medium risk
Electrical hazards activated in the event of a short circuit or fault parts that can become → due to the damaging effects of overloading, short circuit possible → burns, fire, electric shock	F3*C4=RM5-6 High risk	continuous maintenance of the machines is necessary, if a fault is detected it is forbidden to use the machine until the fault has been rectified.	F3*C3=RK3-4 Medium risk

4. Evaluation

Taking into account the risk assessment and based on our observations in a workplace with a farming activity in the field of crop production, we have made the following findings. Firstly, we highlight the hazards that were identified as high or medium risks in the risk assessment, where we identified hazards requiring some action during the inspection of each operation.

Hazards relevant to the transport of plant protection products:

- problems can be caused by missing or incomplete safety data sheets,
- transporting materials separately from each other,
- delivery in damaged packaging,
- the risk of inadequate temperature,
- pesticide tipped over in a storage area.

Based on our observations, the biggest problem is that in some cases the safety data sheet was incomplete, which can pose a risk during transport, storage and use, as failure to comply with the requirements set out in the data sheet can lead to accidents.

In this case, the employer must insist that the safety data sheet is complete and must also require compliance with the conditions set out in the safety data sheet and that all the conditions are met.

Pesticide dumping:

Potential sources of higher risk hazards:

- Mechanical hazards: due to inadequately designed packaging or even excessive packaging,

- ergonomic hazards: mainly when the material is handled manually,
- mechanical dumping: where mechanical handling of materials takes place,
- forklift overload.

Both manual and mechanical material handling have their risks, the biggest problem in this case was the inadequate loading bay design at the site we investigated, the limited space available for mechanical handling and the fact that the forklift is driven by an unqualified person. The poor grip design of the packaging could cause it to fall during loading.

Storage of the plant protection product:

Potential sources of higher risk hazards:

- inadequate socket design,
- the contact of materials with each other,
- a warehouse that cannot be closed properly,
- lack of cleanliness,
- weather conditions (too hot, too cold),
- inadequate ventilation,
- high concentration of particulate matter and gas mixtures,
- inadequate task performance,
- lack of registration,
- material handling,
- packaging that does not comply with the regulations.

As can be seen from the hazards, this is a critical step in the pesticide application process, there are many requirements to be met, and therefore there are gaps and factors that need to be improved to ensure safe and healthy working conditions, mainly that it is difficult to clean up spills and spills due to poor substrate coverings, and therefore clean-up is not achieved, as spills and spills often remain. Sometimes the room is used for other purposes than storage and weighing, and sometimes it is left open, allowing unauthorised persons to enter the storage room. If large quantities of pesticides are stored, the room becomes congested, which also makes it difficult to move the material. For some pesticides, the concentration of particulate matter may exceed the prescribed concentration.

Preparing the crop protection machine, setting up the sprayer:

Hazard sources:

- missed inspection for the sprayer,
- not well maintained,
- mechanical hazards: moving parts can be a problem,
- electrical hazards: short circuit or activation in fault condition,
- hot surface,
- noise hazards: machine noise, engine noise.

The noise from the sprayer and power machine preparation, caused by the movement of worn parts and engine noise, can cause hearing damage and it is therefore essential that the machines are regularly maintained and repaired according to the manufacturer's instructions, until the problem is solved, another machine should be used. The cardan shaft was not fitted with a suitable guard and we have recommended that the guard be replaced. Continue to carry out inspections of the sprayer at the required time.

Making the spray:

Potential sources of danger:

- working with dangerous substances,
- insufficient care, unknown material properties,
- accessibility,
- wrong mixing tank,
- dilution not according to the specifications.

We observed that the spray was not prepared in the right mixer, that the right personal protective equipment was not used, or that the equipment used to prepare the spray was used elsewhere. To reduce the risks from these hazards, we have recommended that the spray should be prepared in the tank of the sprayer or in a mixing tank that is resistant to the substance it contains. Use personal protective equipment as directed and do not eat, drink or smoke while using the product. The equipment used for mixing must not be used elsewhere.

Spraying:

Potential sources of danger:

- using the wrong type of plant protection product,
- the unknown properties of the material,
- dispersion,
- waiting time,
- inappropriate use of personal protective equipment,
- working with highly toxic, toxic substances.

One very important observation was the lack of use of non personal protective equipment during spraying and the fact that spraying was carried out in inappropriate weather conditions. Workers did not have adequate and professional first aid knowledge and follow-up.

To avoid these risks in the future, it is very important to take into account the weather conditions and to use personal protective equipment, because at any time you may have to get out of the machine, where the possible dispersion of the material may pose a risk. Otherwise, when working, the doors and windows of the power machinery must be kept closed. A worker must be designated to receive training in first aid.

Residue management/waste management:

Potential sources of danger:

- residual spray juice,
- residual plant protection product,
- packaging material,
- personal protective equipment and other equipment used,
- use of an expired pesticide.

From what we have seen, expired pesticides are often used for economic reasons, and packaging is sometimes burned, just as personal protective equipment is not treated as hazardous waste. To eliminate these problems, it has been proposed to set up a hazardous materials storage facility and have it disposed of at specified intervals. Expired pesticides should be collected separately and treated as hazardous waste. The use of personal protective equipment is recommended for the collection of residues and waste.

Sprayer cleaning:

Hazard sources:

- washing the machine,
- spraying concentrated spray.

The sprayer may not be cleaned properly, spray may remain in the tank and the sprayer may be stored as such. In order to avoid this, it is necessary to rinse it several times with plenty of water and detergent, check its cleanliness and use personal protective equipment during cleaning.

Throughout the entire application process, it is important to maximise the number of employees in order to minimise the number of workers exposed to the dangerous substance, and also to organise the number of working hours, so that the rested worker can concentrate better, make fewer mistakes and of course it is very important to be properly qualified.

5. Summary

The aim of our research was to assess the risks from the use of pesticides.

To ensure safe and healthy working conditions and to reduce the number of accidents and occupational diseases in agriculture, all laws and regulations must be complied with. It is necessary to obtain permits, carry out regular inspections, use personal protective equipment, know the requirements of the manufacturer's instructions and safety data sheets, and strictly observe and comply with them. It is very important and essential that both the employer and the workers know and fulfil their obligations so that everyone can do their job safely.

6. Acknowledgements

The research was carried out in the framework of the GINOP-2.3.2-15-2016- 00010 “Development of enhanced engineering methods with the aim at utilization of subterranean energy resources” project of the Research Institute of Applied Earth Sciences of the University of Miskolc in the framework of the Széchenyi 2020 Plan, funded by the European Union, co-financed by the European Structural and Investment Funds.

References

[1] Ábrahám, R., Érsek, T., Kuroli, G., Németh, L., Reisinger, P. (2011). *Növényvédelem*. 1. fejezet.

[2] Allsop, M., Huxdorff, C., Johnston, P., Santillo, D., Thomson, K. (2015). *A növényvédő szerek hatásai az emberi egészségre*. Greenpeace Magyarországi Egyesület, pp. 3.

[3] Keszthelyi, S. (2019). *Zoocidek a növényvédelem szolgálatában*. *Rovar-, atka-, csiga- és rágcsálóirtó készítmények bemutatása*. Magyar Agrár- és Élettudományi Egyetem. Agroinform Kiadó. 7. fejezet

[4] Petesné, H. A. *Hogyan hajtsuk végre a növényvédelmi munkákat a legkörültekintőbb módon*. Szakképzési és Felnőttképzési Intézet, pp. 3-5.

[5] OMMF (2022). *Általános munkavédelmi tájékoztató mezőgazdasági ágazatban tevékenykedők részére*. GINOP projekt, pp. 4-12.

[6] Algimantas, M., Ramunas, M., Gediminas, V. (2020). *Agriculture - Use of pesticides/plant protection products*. Aleksandras Stulginskis University, Lithuania.

[7] Bagi, F., and Bodnár, K. (2011). *Növényvédelmi ismeretek*. Szegedi Tudományegyetem, Mezőgazdasági Kar, pp. 30-40.

[8] Lorenz, E. S. (2009). *Potenctial healt effects of pesticides*. Pennsylvania State University, pp. 1-3. Letöltési ideje: 2022.09.17.