Potential Risks of Production Contamination in Urban Agriculture

Assist. Prof. Milena Yordanova*, Assoc. Prof. Vera Petrova, Assistant Tsvetelina Nikolova, Assistant Elena Tsvetkova
University of Forestry – Sofia
*E-mail: yordanova_m@yahoo.com

Citation: Yordanova, M., Petrova, V., Nikolova, T., Tsvetkova, E. (2020). Potential Risks of Production Contamination in Urban Agriculture. *Ikonomika i upravlenie na selskoto stopanstvo,* 65(4), 74-78 (Bg).

Abstract

The migration of people from small settlements to the large cities is a lasting trend because of most of the opportunities they offer. The increase in population leads both to redevelopment and reduction of arable land, and to an increase in the city's food needs. These trends again put forward the theme of urban agriculture. Through it, the satisfaction of the population with food can be achieved within the city, as much of the green spaces in and around it become a source of fresh food.

But urban agriculture also carries risks. They come from heavily polluted air, especially in big cities or places with heavy traffic. Contamination of production can also occur from other sources, especially in areas close to industrial areas, as well as from places with heavy traffic. Vegetable crops, which are usually grown in this agriculture, can accumulate heavy metals, and consuming them fresh can contribute to deteriorating human health.

The aim of the article is to consider some potential risks of contamination of urban agricultural products.

Key words: air pollution; heavy metals; soil pollution; urban agriculture

Потенциални рискове от замърсяване на производството при земеделие в градска среда

Доц. Милена Йорданова*, Доц. Вера Петрова, Асистент Цветелина Николова, Асистент Елена Цветкова
Лесотехнически университет – София
*E-mail: yordanova_m@yahoo.com

Резюме

Миграцията на хора от малките населени места към големите градове е трайна тенденция поради повечето възможности, които градовете предлагат. Увеличаването на населението води както до преустройство и намаляване на обработваемата земя, така и до увеличаване на хранителните нужди на града. Тези тенденции отново поставят темата за градското земеделие. Чрез него може да се постигне удовлетвореността на населението с храна в града, тъй като голяма част от зелените площи в и около него се превръщат в източник на прясна храна.

Но градското земеделие носи и рискове. Те идват от силно замърсения въздух, особено в големите градове или места с интензивен трафик. Замърсяване на производството може да възникне и от други източници, особено в райони в близост до индустриални зони, както и от места с интензивен трафик. Зеленчуковите култури, които обикновено се отглеждат при това земеделие, могат да натрупват тежки метали и консумацията им в прясно състояние да доведе до влошаване на човешкото здраве.

Целта на статията е да разгледа някои потенциални рискове от замърсяване на селскостопанските продукти, отглеждани при градско земеделие.

Ключови думи: замърсяване на въздуха; тежки метали; замърсяване на почвите; градско земеделие

Migration and urban agriculture

More than half of the world's population (55.3%) lives in urban areas according to data for 2018. Data for Europe show a higher percentage of urban population (74.5%) than the aggregated data for the world, as for Bulgaria the data are not much different – 75% of the country's inhabitants are in the cities (United Nations[а,б], 2018). According to forecast data from 2014, the share of urban population in Bulgaria is expected to continue to grow and reach 81% by 2050, but according to analyzes from 2018, forecasts are higher – 85% of the population will located in cities until 2050.

One of the elements for sustainable urban development is urban agriculture. It produces food, provides employment and improves economic security. Its advantage is that it has low capital investment and leads to improved environment. It can be said that urban agriculture contributes to social stability while increasing environmental sustainability (Smit, J. et al., 1992). Over the centuries, urban agriculture has developed and changed, along with the development and expansion of cities. It was originally more specialized animal husbandry (15^{th} century), going through the industrialization of horticulture (19^{th} century) to public gardens and urban horticulture at the moment (Lohrberg, 2016). Urban agriculture includes the production of plant and animal goods not only in cities and districts (Zezza and Tasciotti, 2010), but also in interurban agricultural areas that can provide a product to the local population, such as vegetables, herbs, fruit crops, ornamental plants, milk, meat and wool (Lin et al., 2015). It can take various forms: traditional cultivation - on agricultural land on the outskirts of cities, in yards and gardens and agriculture with zero areas (so-called "Zfarming"), which uses walls, facades, terraces and roofs of buildings, as well as within them (Thomaier, S. et al., 2014; 2015).

Potential risks of contamination

The urban environment can pose a risk for growing plant products, which is mainly related to air and soil pollution. This problem has been raised for a long time (back in 1978 at a conference in New York, USA), but is often underestimated. Issues related to the assessment of potential risks to urban gardening in the presence of heavy metals in the air or soil, as agricultural products with traces of heavy metals, can lead to a significant risk to human health (Massaquoi et al., 2015). A study on the accumulation of heavy metals in plants grown in urban agriculture in Seoul shows that there are two ways in which heavy metals can accumulate in plants grown in urban agricultural areas, such as roof gardens in Seoul: uptake from soil by the roots and deposition of leaf surface from the air (Kim, H. S. et al., 2015). Heavy metals such as Pb, Cd, Cu and Zn are considered the most toxic elements in the environment and are listed by the US Environmental Protection Agency (EPA) as a priority pollutant (Cameron, 1992). EU legislation (EU, 2009) regulates the upper limits of Pb and Cd in food products. Antisari et al. (2015) consider that more dangerous elements than Pb and Cd are Cr, Cu, As and Ni, but according to Clemens and Ma (2016), arsenic and cadmium taken with plant foods are major potential hazards to human health.

Air pollution

Urban areas are hotspots for energy, water and materials, as well as for consumption and waste production, and as such are a major source of greenhouse gas production. Urban air pollution has intensified in recent decades due to strong industrialization, rapid urban population growth, human activities (e.g. burning of fossil fuels), increasing car traffic, etc. (Agrawal et al., 2003; Alloway, 2004; Kaye et al., 2006; Grimm et al., 2008).

Gardens and agricultural areas located near roads can be exposed to air pollution, which in turn can lead to pollution of garden products, exceeding the maximum permissible concentration. Antisari et al. (2015) found that in the leaves of vegetables grown near the main arteries of the city (10 m), the highest levels of pollution are observed compared to those a located further away (60 m). Although higher traffic loads increase the content of heavy metals in crop biomass, the presence of barriers (tall buildings, trees, etc.) between roads and gardens greatly reduces their content (Säumel et al., 2012). A very important conclusion is reached by Sharma et al. (2009) that the presence of heavy metals in vegetables can be detected not only in their production in a polluted urban environment but also in their transportation and supply in such a polluted environment (e.g. open markets and roadside stalls), by surface deposition of heavy metals. Amato-Lourenco et al. (2017) found that vegetable crops with a short growing cycle did not accumulate harmful substances when grown in urban environments.

Soil pollution

During studying and comparing different vegetable species grown in urban and rural environments, differences in heavy metal indicators are observed, which are higher in vegetables grown in cities (Demirezen and Aksoy, 2006).

Pollution of urban soils can occur for various reasons, but mainly because they are often located near urban sites affected by human activities, such as industrial production, traffic, landfills etc. (Jean-Soro et al., 2015). They may contain hazardous substances (As, Hg, Cd, Co, Cr, Cu, Mn, Mo, Ni, Pb, Sn, Zn and Se) that are assimilated by plants. Some of the strongest pollutants with heavy metals in the soil are unregulated sludge, recycled automotive fuels, wastewater etc. (Singh et al., 2005; Khan et al., 2008). Soils located closely to industrial areas with a chemical industry are also often contaminated with heavy metals. These soils have an unfavorable water-air regime and also imbalance in macronutrient nutrition can be observed (Atanasova et al., 2015).

Differences in the accumulation of heavy metals in plants have been found. It is related not only to their level in the soil, which determines their rate of absorption by vegetables, but also depending on plant type and the length of their growing season. Studies show that lead does not accumulate easily in the fruit-bearing parts of vegetable and fruit crops (e.g. in corn, beans, pumpkin, tomatoes, strawberries, apples). Higher concentrations are likely to be observed in leafy vegetables (e.g., lettuce, amaranth) and on the surface of root crops (e.g., carrots) (Rosen, 2002; Hao et al., 2009).

Lead can be taken in two ways: from the roots of the plant and then transported to the leaves, or through the air. Lead that accumulates on the leaves can be washed away by washing the leaves, especially when the leaf surface is waxy (cruciferous and onion).

In the same way, cadmium can be absorbed by plants through roots and leaves. Therefore, the location of vegetable gardens should be chosen carefully in regard to roads and polluting industries (Antisari et al., 2015).

In order to make a more accurate assessment of the level of soil contamination with heavy metals, it is important to know not only their general concentrations but also their specific forms or bound state, because the toxicity and mobility of these heavy metals depend on them (Cornelis, 2002; Abul Kashem et al., 2007). For example, iron fractions of manganese oxide are relatively stable under normal conditions. The organic phase is also relatively stable in nature, but it can be mobilized under strong oxidative conditions upon decomposition of organic matter, resulting in the release of soluble metal (Banat et al., 2005).

In Europe, private gardens in the city are cultivated mainly by the elderly population, who use traditional practices often associated with the use of fertilizers, herbicides and pesticides (Szolnoki et al., 2013). A study conducted in Germany in 2001 showed that 90% of urban gardeners use pesticides (UM, 2014) to kill pests, but these pesticides can have a negative impact on beneficial garden fauna (e.g. pollinators, biological enemies of pests), as well as to cause pollution of water, air and soil, and from there food contamination occurs. For these reasons, pesticide use has been restricted or even banned in private gardens in recent years, along with the growing awareness of gardeners (Barthel et al., 2010; Voigt et al., 2016).

Excessive application of fertilizers can lead to soil and water contamination with nitrates and phosphates, which is common among hobby farmers due to their poor agricultural knowledge (Tixier and de Bon, 2006).

Wood ash is traditionally discarded in the garden because it is rich in potassium and can increase the permeability of clay soils. This ash can is high in Pb, Zn, Cd, Cr and other elements if the wood has been painted. The resurgence of the use of wood stoves in the United States encouraged the burning of wood waste; some are painted and this ash can is very rich in Pb. During the incineration of household waste enriched with metal, such as painted old furniture, windows, etc., the soils on which the event was carried out are polluted. Such soils most often contain over 5000 ppm Pb and high Zn and Cd. The burning of tires contaminates the soil with Zn because the rubber contains 0.5 to 4% Zn. (Alloway, B. J., 2004).

Conclusion

Growing vegetables in an urban environment hides some risks arising from the specifics of the city. Increased traffic, as well as industry and human activity, lead to air and soil pollution with heavy metals.

Some possibilities for counteracting the contamination of the production are indicated: careful selection of the place during ground cultivation, if possible the presence of barriers (trees, walls), from the source of pollution, as well as selection of the plant types for cultivation, but not yet well studied. Further studies are needed on the areas of air and soil pollution and the possibilities for prevention of plant production from heavy metal pollution.

Acknowledgment

To project N–B–1009/27.03.2019 "Study of ecological and agro-technological aspects for breeding agricultural products and bees in aggravated urban environment". Funded by Scientific Sector at University of Forestry.

Reference

Agrawal, M., Singh, B., Rajput, M., Marshall, F., & Bell, J. N. B. (2003). Effect of air pollution on peri-urban agriculture: a case study. *Environmental Pollution*, *126*(3), 323-329.

Alloway, B. J. (2004). Contamination of soils in domestic gardens and allotments: a brief overview. *Land contamination and reclamation*, *12*(3), 179-187.

Amato-Lourenco, L. F., Saiki, M., Saldiva, P. H., & Mauad, T. (2017). Influence of air pollution and soil contamination on the contents of polycyclic aromatic hydrocarbons (Pahs) in vegetables grown in urban gardens of Sao Paulo, Brazil. *Frontiers in Environmental Science*, *5*, 77.

Antisari, L. V., Orsini, F., Marchetti, L., Vianello, G., & Gianquinto, G. (2015). Heavy metal accumulation in vegetables grown in urban gardens. *Agronomy for sustainable development*, *35*(3), 1139-1147.

Atanasova, E., Atanasova, I., Simeonova, T., Nenova, L., Teoharov, M., & Stoykova, M. (2015). Assessment of the nutritional status of arugula (Eruca sativa) in technogenic soils. Soil Science Agrochemistry and Ecology, Year XLIX, № 1, pp. 65-71.

Banat, K. M., Howari, F. M., & Al-Hamad, A. A. (2005). Heavy metals in urban soils of central Jordan: should we worry about their environmental risks?. *Environmental research*, *97*(3), 258-273.

Barthel, S., Folke, C., & Colding, J. (2010). Social–ecological memory in urban gardens–Retaining the capacity for management of ecosystem services. *Global Environmental Change*, *20*(2), 255-265.

Cameron, R. E. (1992). Guide to site and soil description for hazardous waste site characterization. Volume 1: Metal. Environmental Protection Agency EPA/600/4-91/029. Washington, DC: US EPA. http://nepis.epa. gov/EPA/html/Pubs/pubtitleORD.htm

Carl, J. (2002). Rosen Lead in the Home Garden and Urban Soil Environment. Extension Research Soil Scientist Department of Soil, Water and Climate.

Clemens, S., & Ma, J. F. (2016). Toxic heavy metal and metalloid accumulation in crop plants and foods. *Annual review of plant biology*, *67*, 489-512.

Cornelis, R. (2002). Speciation of trace elements: a way to a safer world. *Analytical and Bioanalytical Chemistry*, *373*(3), 123-124.

Demirezen, D., & Aksoy, A. (2006). Heavy metal levels in vegetables in Turkey are within safe limits for Cu, Zn, Ni and exceeded for Cd and Pb. *Journal of food quality*, *29*(3), 252-265.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. *science*, *319*(5864), 756-760.

Hao, X. Z., Zhou, D. M., Huang, D. Q., Cang, L., Zhang, H. L., & Wang, H. (2009). Heavy metal transfer from soil to vegetable in southern Jiangsu Province, China. *Pedosphere*, *19*(3), 305-311.

Jean-Soro, L., Le Guern, C., Bechet, B., Lebeau, T., & Ringeard, M. F. (2015). Origin of trace elements in an urban garden in Nantes, France. *Journal of Soils and Sediments*, *15*(8), 1802-1812.

Kashem, M. A., Singh, B. R., & Kawai, S. (2007). Mobility and distribution of cadmium, nickel and zinc in contaminated soil profiles from Bangladesh. *Nutrient Cycling in Agroecosystems*, *77*(2), 187-198.

Kaye, J. P., Groffman, P. M., Grimm, N. B., Baker, L. A., Pouyat, R. V. (2006). A distinct urban biogeochemistry? Trends in Ecology & Evolution, 21: 192-199.

Khan, S., Cao, Q., Zheng, Y. M., Huang, Y. Z., & Zhu, Y. G. (2008). Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. *Environmental pollution*, *152*(3), 686-692.

Kim, H. S., Kim, K. R., Lim, G. H., Kim, J. W., & Kim, K. H. (2015). Influence of airborne dust on the metal concentrations in crop plants cultivated in a rooftop garden in Seoul. *Soil science and plant nutrition*, *61*(sup1), 88-97.

Lin, B. B., Philpott, S. M., & Jha, S. (2015). The future of urban agriculture and biodiversity-ecosystem services: Challenges and next steps. *Basic and applied ecology*, *16*(3), 189-201.

Lohrberg, F., Lička, L., Scazzosi, L., & Timpe, A. (Eds.). (2016). *Urban agriculture europe*. Jovis.

Massaquoi, L. D., Ma, H., Liu, X. H., Han, P. Y., Zuo, S. M., Hua, Z. X., & Liu, D. W. (2015). Heavy metal accumulation in soils, plants, and hair samples: an assessment of heavy metal exposure risks from the consumption of vegetables grown on soils previously irrigated with wastewater. *Environmental Science and Pollution Research*, *22*(23), 18456-18468.

Säumel, I., Kotsyuk, I., Hölscher, M., Lenkereit, C., Weber, F., & Kowarik, I. (2012). How healthy is urban horticulture in high traffic areas? Trace metal concentrations in vegetable crops from plantings within inner city neighbourhoods in Berlin, Germany. *Environmental Pollution*, *165*, 124-132.

Sharma, R. K., Agrawal, M., & Marshall, F. M. (2009). Heavy metals in vegetables collected from production and market sites of a tropical urban area of India. *Food and chemical toxicology*, *47*(3), 583-591.

Singh, A. N., Zehg, D. H., & Chen, F. S. (2005). Heavy metal concentrations in redeveloping soil of mine spoil under plantations of certain native woody species in dry tropical environment, India. *Journal of Environmental Sciences*, *17*(1), 168-174.

Smit, J., & Nasr, J. (1992). Urban agriculture for sustainable cities: using wastes and idle land and water bodies as resources. *Environment and urbanization*, *4*(2), 141-152.

Thomaier, S., Specht, K., Henckel, D., Dierich, A., Siebert, R., Freisinger, U. B., & Sawicka, M. (2015). Farming in and on urban buildings: Present practice and specific novelties of Zero-Acreage Farming (ZFarming). *Renewable Agriculture and Food Systems*, *30*(1), 43-54.

Tixier, P., De Bon, H., & Holmer, R. (2006). Urban horticulture. Cities farming for the future: Urban agriculture for green and productive cities. *Ottawa: ETC-UA/RUAF, IDRC*.

Voigt, A., & Leitão, T. E. (2016). Lessons learned: indicators and good practice for an environmentally-friendly urban garden. In *Urban Allotment Gardens in Europe* (pp. 187-220). Routledge.

Zezza, A., & Tasciotti, L. (2010). Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries. *Food policy*, *35*(4), 265-273.

EC. (2011). Commission Regulation (EU) No 420/2011 of 29 April 2011 amending Regulation (EC) No 1881/2006 setting maximum levels for certain contaminants in foodstuffs. *Official journal of the european union*, *111*, 3-6.

UM. (2014). (Umweltinstitut München): Pestizide (Pesticides). URL: http://www.umweltinstitut.org/themen/landwirtschaft /pestizide/glyphosat/haus-und-kleingarten.html.

United Nations. Department of Economic and Social Affairs. (2018)[a]. Population Division World Urbanization Prospects: The 2018 Revision. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

United Nations. Department of Economic and Social Affairs. (2018)[b]. Population Division World Urbanization Prospects: The 2018 Revision. Highlights https://population.un.org/wup/Publications/Files/WUP2018-Highlights.pdf