TOXICITY OF FIVE POTASSIUM SALTS TOWARDS DUCKWEED (*LEMNA MINOR*)

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Abstract: A study about aquatic toxicity of potassium sorbate, potassium nitrate, potassium chloride, potassium permanganate and potassium metabisulfite salts towards *Lemna minor* (duckweed) was conducted. The examined salts have numerous applications in human areas including in agriculture as fertilizers or as biocide agents. Tested chemicals are completely water soluble, and used in large amounts all over the world which made their impact on water ecosystems significant. Duckweed is a standard test object for ecotoxicological examinations. The results show that all of the tested compounds can be classify as low toxic towards *lemna minor*. However, two of them potassium metabisulfite and potassium permanganate express more toxic action with LC50 = 41 ppm for potassium metabisulfite and LC50 = 220 ppm for potassium permanganate. Potassium chloride was the lowest toxicity towards tested plants (LC50 = 220 000 ppm). One of the most popular fertilizers in agriculture, potassium nitrate, however, shows toxicity, although at low levels (LC50 = 24 000 ppm). Due to the fact, that the same chemical is used widely in the world as fertilizer in large amounts, its application must be taken into consideration especially nearby small water bodies. One of the most popular food preservatives in the world, potassium sorbate also was found to has (although low) toxicity towards *Lemna minor*.
Keywords: *Lemna minor*, duckweed, potassium sorbate, potassium nitrate, potassium chloride, potassium metabisulfite, potassium permanganate

1. INTRODUCTION

Duckweed (*Lemna minor*) is a floating aquatic plant consisting of a single oval or oval-obovate thallus, it is about 2-5 mm long and 1.5-3.5 mm across. The plant often forms dense colonies on water which can cover almost all of the aquatoria of small water bodies. The whole plant was used as antipruritic, antiscorbutic, astringent, depurative, diuretic, febrifuge and soporific. It was also used in the treatment of colds, measles, edema and difficulty in urination (Al-Snafi, 2019). The plant can be used for making biofuel too (Kaur et al., 2019). Duckweed is widely used in the heavy metals removal, wastewater treatment and phytoremediation of chemicals in the environment (Axtell et al., 2019; Ceschin et al., 2020). Also in the genetic research and studies of different plant physiological and biochemical processes (Wang et al., 2016). The plant is also a standard organism for exotoxicological evaluation of aquatic toxicity of the chemicals (Radić et al., 2010; Loll et al., 2022;) including assessment of different kinds of antibiotics or other molecules used as drugs in the medicine (Pop et al., 2021; Nunes et al., 2014) and of course – pesticides, biocides and fertilizers (Huang et al., 2014; Doganlar, 2012). Other studies reveal an allelopathic potential of *Lemna minor* (Gostyńska et al., 2022).

In the present study, the toxicity of several potassium salts towards *Lemna minor* was evaluated. These salts were:

- potassium sorbate
- potassium nitrate
- potassium metabisulfite
- potassium chloride
- potassium permanganate

All of these salts are used in agriculture as pesticides or fertilizers. Potassium sorbate ($C_6H_7KO_2$) is a white–brownish dust, very often sold and used as fine granules, which is a typical food preservative (E202) including in personal-care products. Potassium sorbate has a strong mold inhibitory effect which makes it applicable in plant protection too including for post-harvest treatments (Liu et al., 2014; Feliziani et al., 2013; Nikolov & Ganchev, 2011). The chemical is very soluble in water which is one more plus its application as a fungicide. Additionally salt has very low toxicity – the estimated LD50 for a rat is 4340 ppm although can be skin, eye, and respiratory irritant in concentrations over 0.5 % (Dehghan et al., 2018; Younes et al., 2019). Under some conditions, particularly at high concentrations or when combined with nitrites, potassium sorbate has shown genotoxic activity in vitro (Mamur et al., 2010).

According to fishes however the LC50 is only 500 ppm, aquatic invertebrates – 982 ppm and algae – 221 ppm. The salt is not classified as hazardous to the aquatic environment (Engel et al., 2015; Li et al., 2017). Potassium nitrate (KNO_3) is a typical inorganic fertilizer used widely in agriculture as a source of nitrogen. The chemical occurs in nature as a mineral, niter. Other uses of potassium nitrate include the preparation of gunpowder as an oxidizer (Banchetti-Robino, 2012). In pest management, potassium nitrate is typically used as a tree stump removal agent, also to induce the flowering of mango trees. Also as molluscicide against *Limacolaria spp*. (Cheke et al., 2020). The

salt is with low toxicity towards mammals (LD50 = 3750 ppm oral rat) and can cause sore throat, cough if inhaled, or redness on skin or eyes . The chemical is not classified as hazardous to the aquatic environment - LC50 acute toxicity for fish is over 100 ppm, for aquatic invertebrates – 490 ppm, and for algae – over 1700 ppm (Mortensen et al., 2017).

Potassium chloride is a common white crystal salt used as a fertilizer, water softener, soap manufacturer, and food additive (E508). It occurs naturally as the mineral sylvite, and in combination with sodium chloride as sylvinite (Cepanec et al., 2017). LD50 for acute toxicity towards mammals is over 2600 ppm (oral rat). The salt is not classified as hazardous to the aquatic environment: LD 50 acute toxicity for fish is 880 ppm; for aquatic invertebrates- 670 ppm, for algae – 100 ppm (Meneely et al., 1957; Wang et al., 2018).

Potassium metabisulfite ($K_2S_2O_5$) is a white crystal water soluble powder, widely used as an antioxidant and antimicrobial agent included in the food industry as a food preservative (mainly wine and beer) under the name E224 (Younes et al., 2022). However there is a restriction on its use due to allergic reactions. Other research shows a genotoxic effect of potassium metabisulfite (Ortiz et al., 2014). Just like potassium sorbate due to its antimicrobial properties can be used as a fungicide in pest management too. There are also studies that reveal potential repellent properties of the salt towards *Drosophila suzukii* (Kasnazany et al., 2017; Khayyat et al., 2018). LD50 for acute toxicity towards mammals is 1800 ppm, but chemical is classify as Category 1 as eye irritant. However the skin irritation is very low. The salts also have very low toxicity towards fishes : 1000 ppm LD50 acute toxicity (EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF), 2016).

Potassium permanganate ($KMnO_4$) is an extremely popular chemical in chemical manufacture, used as oxidizing and also as chemiluminescence agent (Shaabani et al., 2005). Salt is also very popular in medicine (including veterinary) as biocide agent for the disinfections of wounds or as a medication for dermatitis (Darwish et al., 2008). The compound found application in pest management too as relatively safe for humans and the environment fungicide (Obieglo, 1991; Zuparov et al., 2020). Unlike other chemicals tested in this study, potassium permanganate is classified as harmful if swallowed. The compound can also cause severe skin burns and eye damage and is suspected of damaging the unborn child. However LD50 for mammals oral/dermal low - is over 2000 ppm. LC50 for fish acute toxicity is only 0.47 ppm – moderate toxic, for aquatic invertebrates – 0.06 ppm – high toxic and for algae – 0.8 ppm – moderately toxic.

2. MATERIALS AND METHODS

Water solubility of tested salts is:

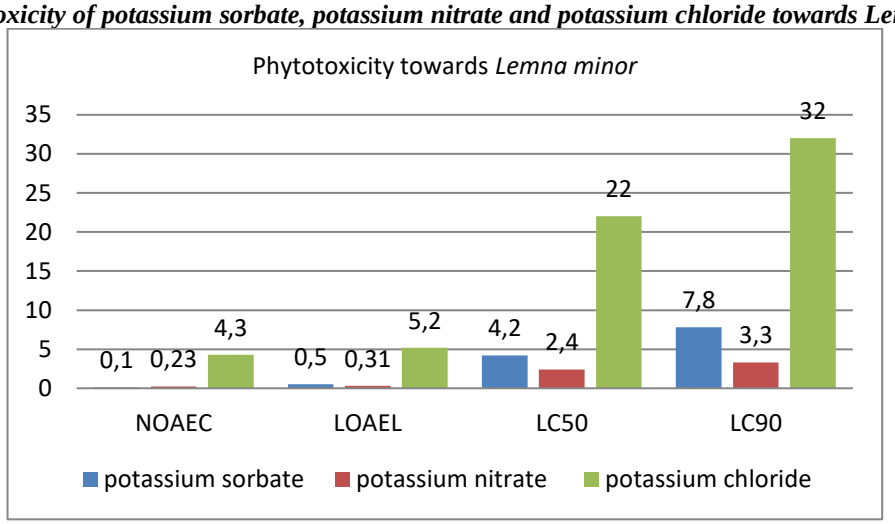
- potassium sorbate water solubility : 543 g/l at 20°C
- potassium nitrate : 320 g/l at 20°C
- potassium chloride: 355 g/l at 20°C
- potassium metabisulfite: 45 g/l at 20°C
- potassium permanganate: 64 g/l at 20°C

Fronds from duckweed (*Lemna minor*) naturally inhabited river "Nevolja" in village Vasil Levski, Plovdiv district, Bulgaria, were used in the current trials. The plants were grown in the same river water in laboratory conditions. Plastic cup from chemically inert material with 200 ml volume were used and in each cup, 150 ml water solution of tested salt in the given concentration was placed. Each test variant consisted of 5 plastic cups with duckweed (replicates). The number of fronds and colonies was the same in each test vessel. The tests were visually examined 7 days after the plants are transferred into the test vessels and frond numbers appearing normal or abnormal were determined every 3 days from the beginning of the test. Changes in plant development, e.g. in frond size, appearance, an indication of necrosis, chlorosis or gibbosity, colony break-up or loss of buoyancy, and in root length and appearance were visually observed (Alkimin et al., 2019; Loll et al., 2022). Dose – Response Modeling was performed via R language for Statistical Computing and drc packge (Ritz et al., 2016) and NOAEC (No Adverse Effect Concentration), LOAEL (Lowest Adverse Effect Concentration), LC50 (Lethal concentration – 50 %) and LC90 (Lethal concentration – 90 %) were determined (Ihaka & Gentleman, 1996; Crawley, 2012) and NOAEC (No Adverse Effect Concentration), LOAEL (Lowest Adverse Effect Concentration), LC50 (Lethal concentration – 50 %) and LC90 (Lethal concentration – 90 %) were determined (Yu, 2006; Wilson & Koch, 2013; Davies et al., 2003)

3. RESULTS

Figure 1 present received result from conducted trials with potassium sorbate, potassium nitrate and potassium chloride.

Figure.1 Toxicity of potassium sorbate, potassium nitrate and potassium chloride towards Lemna minor



The results show that potassium chloride is almost safe for the tested plants. The concentration at which is able fully to destroy duckweed is up to the boundary of its water solubility. Up to the 4 % (m/v) concentration, KCL does not cause any visual damage to *Lemna minor*. Although potassium nitrate is popular fertilizer in agriculture, tests reveal that this chemical can be too toxic for aquatic plants. Above 5.3 % (m/v) concentration, KNO_3 can destroy the duckweed plants, and only at 0.2 % (m/v) can be safe for them. This result show that applications of this fertilizer nearby water basins must be done with attention especially when the salt is applied in large amounts nearby small water bodies. Logically the most toxic to *Lemna minor* compound in this set of trials was potassium sorbate which is widely used as a biocide agent (food preservative or fungicide). Although it is safe for humans and mammals, the salt is not classified as hazardous to the aquatic environment (LC50 for fishes is 0.05 % and for algae – 0.02 %), conducted trials with *Lemna minor* shows that towards this plant the toxicity of potassium sorbate is even lower: LC 50 = 4.2 % (m/v). Under 0.1 % (m/v) concentration, potassium sorbate does not cause any visual damage to duckweed

Figure. 2 In the left picture – Control variant; in the right picture – KCL at 10 % (m/v) concentration

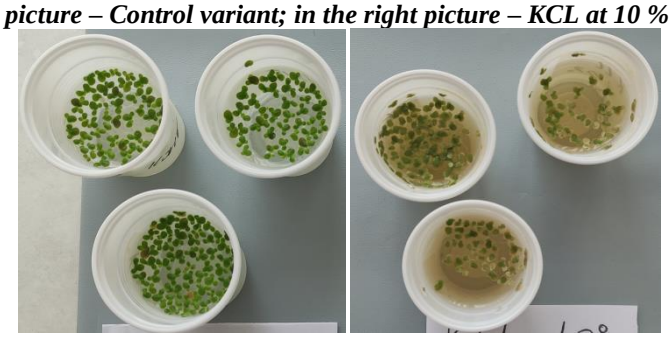


Figure.3 In the left picture – KNO_3 at 5.3 % (m/v) concentration; in the right picture - potassium sorbate at 4 % (m/v) concentration

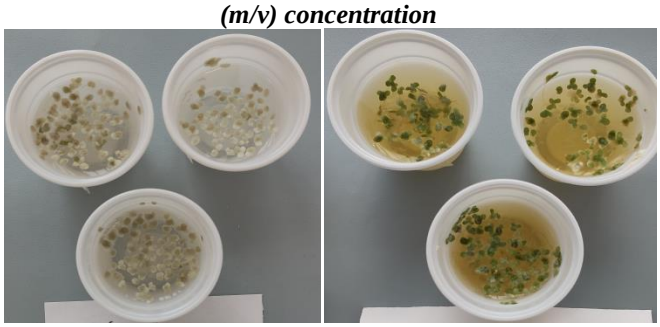
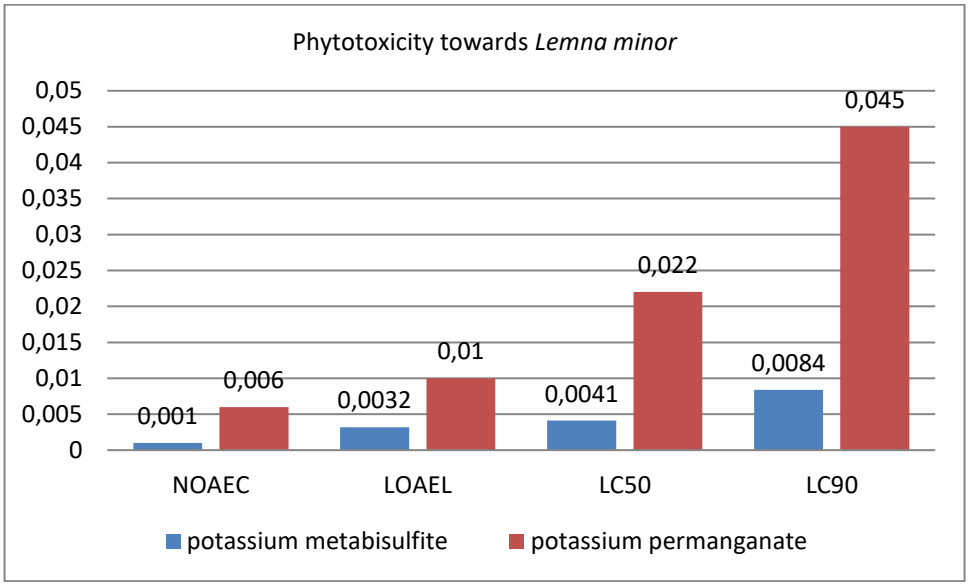


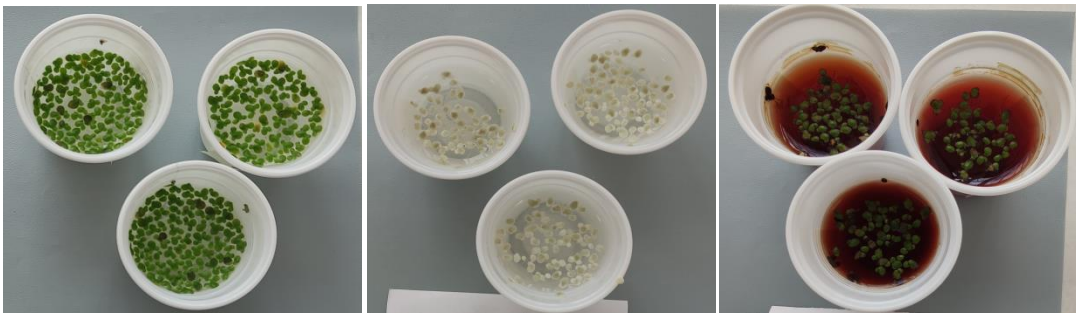
Figure 4 present received result from conducted trials with potassium metabisulfite and potassium permanganate.

Figure.4 Toxicity of potassium metabisulfite and potassium permanganate towards Lemna minor



Unlike the other three chemicals, however potassium metabisulfite and potassium permanganate show more significant toxicity toward *Lemna minor*. LC50 for potassium metabisulfite was 0.0041 % (m/v) but these values still classify it as a low toxicity chemical towards aquatic plants. A concentration of 0.001 % (m/v) was safe for duckweed, although this chemical is used as a food preservative with very low toxicity towards humans (mammals) and LC50 for fishes is low = 0.1 % concentration. Potassium permanganate although is a moderate acute toxic for fishes and algae and very toxic for aquatic invertebrates, conducted trials show its low toxicity towards *Lemna minor*, estimated LC50 was 0.0041 % (m/v) concentration (41 ppm).

Figure. 5 In the left picture – potassium metabisulfite at 0.001 % (m/v) concentration; in the middle picture - potassium metabisulfite at 0.01 % (m/v) concentration; in the right picture - potassium permanganate at 0.01 % (m/v) concentration



4. DISCUSSIONS

The received results show that tested potassium salts: potassium sorbate, potassium nitrate, potassium chloride, potassium metabisulfite and potassium permanganate can be classified as low toxic chemicals towards duckweed (*Lemna minor*). However, some of them as potassium metabisulfite and potassium permanganate can be more toxic than others.

5. CONCLUSIONS

All tested chemicals show low toxicity toward duckweed (*Lemna minor*). Potassium chloride has almost no toxicity while potassium metabisulfite shows the highest toxic action, although still within the boundaries of low toxicity

levels. Potassium nitrate also shows toxic action toward plants which must be taken into consideration, due to the fact, this chemical is very widely used as an agricultural fertilizer in large amounts, especially, in applications nearby small water basins. One of the most popular food preservative, potassium sorbate also express toxic action towards *Lemna minor*, however much lower than acute toxicity towards fishes or algae. The popular disinfectant in medicine and oxidizing agent, potassium permanganate has toxicity a little bit higher than potassium metabisulfite towards duckweed.

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