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PRELIMINARY STUDY REGARDING THE USE OF MEDICINAL AND DECORATIVE PLANTS IN THE CONCEPT OF PERI-URBAN GARDENS WITH ROLE ON ENVIRONMENTAL PROTECTION

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Abstract

Urban gardening is becoming more and more popular in our day to day lives. The desire for such activity arose due to the massive urban growth, the daily stress and an increasing desire to have fresh fruits and vegetables for personal use. Although the presence of a vegetable garden in a private urban or peri-urban area offers many advantages – a source of fresh vegetables and aromatic plants, as well as a recreational area – it faces a major disadvantage – pollution. In the city there are countless sources of pollution, the most common being the one created by traffic. Having this in mind, the purpose of this paper is to present an overview on selecting medicinal and decorative plants in order to provide protection for vegetables against urban pollution. The results gathered were used to create a list of plants including vegetable, medicinal and floricultural species, which helped to design a planting plan for a vegetable and decorative garden.

Key words*: urban garden, edible landscape, vegetable garden, pollution.*

INTRODUCTION

Since ancient times, cultivating plants has been an integral part of human history. From the human need to feed, the garden appeared as a source of safe and fast food. Initially, the role of a garden was primarily functional, the production of food and medicinal plants being its main purpose, while later on it developed also an additional aesthetic role (Hangan *et al.,* 2018).

In many cities around the world, air pollution is a major problem. When designing a garden, an important factor that must be taken into account is the plants pollution absorption degree.

Urban horticulture is becoming an essential element of urban planning in many cities of the world (Vittori Antisari *et al.,* 2015).

Compared to traditional farming, growing food in the urban area depends on different conditions. In the cities, according to the accessible space, the horticultural gardens are distributed differently (for example, close to main roads), instead of following rational and agronomical aspects (such as potential pollution sources, access to light) (Alloway, 2004).

The concentration of various trace elements from the atmosphere are considerably affected by human actions, and their quantification in atmospheric accumulation can be useful to attribute to different sources of pollution (Vittori Antisari *et al.,* 2013).

Contaminants that are stored in soil, water, and air can affect the product quality and healthiness of the plants (Leake *et al.,* 2009), but not only. These accumulations threaten the health of people too by entering in human bodies through stomach, lungs, and contact with the skin (Timofeev *et al.,* 2019).

The presence, in urban soils, of heavy metals originating from intense human activities, especially road traffic, represent the main risk (Khan *et al.,* 2008; Salvagio Manta *et al.,* 2003). Although, these elements can be absorbed by plants, their accumulation among plant organs and plant species may vary (Säumel *et al.,* 2012). Urban areas contain multiple sources of pollutants with different degrees of intensity. A garden situated on a rooftop or in a courtyard is more protected than a garden located near a railway. Furthermore, researches on heavy metal absorption have established that distance from the road and

pollution are generally inversely associated (Gherardi *et al.,* 2009).
In order to improve the quality of air and soil in a small edible garden, some small decorative and medicinal plants were studied.

MATERIALS AND METHODS

The study presented in this research was done based on the existing studies and information in literature. The main research methods used are the case study regarding the degree of air pollution absorbed by plants and a study based on designing a small vegetable garden replica representing the ideal combination between vegetable plants, decorative and medicinal plants.
The plants that will be studied are the ones commonly used in a private garden.
All the information gathered during this study, will result in a small design simulation of a vegetable garden which will be situated in the experimental field of the Horticulture Faculty in Iasi, "V. Adamachi" farm. The design programs used are AutoCAD 2015 and Photoshop 6.
The area and site for the design will be evaluated and natural factors such as water, soil, light and local fauna will be taken into consideration. The area to be designed has 37 m^2 applied on three modules.
Current methods of assessing tolerance thresholds and risks for agricultural soils are focused on the types of metals (Murray *et al.,* 2009). However, two species of plants grown in the same soil do not present the same risk to human consumers. Different plant species have different abilities to absorb and accumulate metals, both in general and in different types of tissue (Alexander *et al.,* 2006). Spinach leaves (*Spinacia oleracea* L.), for example, contain higher concentrations of Mn than its roots, while in radish *(Raphanus sativus* L.) the highest concentrations of Mn are found in roots. The leaves of plants have a higher concentrations of metal than the stems, so leafy vegetable species grown on contaminated soil may be at a greater risk (Qadir *et al.,* 2000; Harrison, 2001). According to Ramos *et al.* (2002) lettuce (*Lactuca sativa* L.) is considered as potential hyperaccumulator of heavy metals. The concentrations of heavy metals in lettuce shoots and roots rises by increasing the exposure duration (Khan *et al.,* 2015). According to Garate *et al.* (1993), lettuce has higher capacity to accumulate heavy metal in different tissues.
The samples collected by Säumel *et al.* (2012) inside the city have a much higher metal content than the supermarket samples (for example, basil 4.4, nasturtium 1.7, thyme 3.5 and parsley 1.9 times more Cr).
The amount of particulate matter on the leaves of different plant species alongside a road vary according to traffic density, particle type and species. Species with dispersed haired or glabrous leaves captures less particles than plants with densely haired leaves. Plants higher than 15 cm collect more particulate matter than plants lower than 15 cm (Weber *et al.,* 2013).
A small edible garden does not have enough space for large plants to grow thus, some small decorative and medicinal plants that improve the quality of air and soil were studied.
Studies conducted in the literature enumerate as species that can be used the following: yarrow, aster, wild geranium, common ivy, lavender and sage.
Achillea millefolium L., commonly known as yarrow, is one of the species of plants that can be used in the urban environment and can cover a quite large area providing support for the deposition of polluting particles. Due to the hairy and rough appearance of the leaves (Figure 1), the plant can capture a large amount of particles (Weber *et al.,* 2013).
The plant is cultivated as an ornamental plant for gardens and natural landscaping. Even if the plant can grow in less ideal conditions, it prefers a well-drained soil and full sun.

Figure 1. *Achillea millefolium* L. plant detail (https://iransaffronhouse.com/product/achillea-millefolium/)

Aster spp., also known as aster, is one of the types of plants that absorbs heavy metals from the soil such as cadmium, lead and selenium. Also, due to the hairy appearance and the small leaves, *Aster* can capture particles thus preventing the dispersion of this pollutant (Figure 2) (Gabrys, 2018).
Aster is a genus of perennial flowering plants from the family Asteraceae.
The plant has large clusters of flowers in white, pink, lavender, purple and red colours. Although it can tolerate dryness and poor soil it will bloom poorly (Gilman, 1999). Asters blooms forms late summer and autumn.

Figure 2. *Aster* spp. plant detail (https://www.forestryimages.org/browse/detail.cfm?imgnum=5110040)

Aster is sensitive to ozone thus, indicating the high or low presence of this pollutant on the basis of appearance and health of the plant (Gabrys, 2018).
It can be used in borders, rock gardens, or wildflower gardens. It attracts butterflies and bees, providing the pollinators with a late-season supply of nectar Gilman, 1999).
Geranium maculatum L., or wild geranium, contributes to urban biodiversity by attracting pollinators due to flowers. The palmately lobed leaves situated at the base are large and appear in spring. The lower leaf surface has rough white hairs while the upper surface is covered with fine white hairs that helps capturing the particles (Figure 3) (Gabrys, 2018).
It is a perennial plant known as wild geranium or spotted geranium. It is an herbaceous plant growing up to 60 cm in high and flowers in spring to early summer. The flowers are rose-purple, pale or violet-purple.

Figure 3. *Geranium maculatum* L. underside leaf detail (https://wimastergardener.org/article/wild-geranium-geranium-maculatum/)

The plant is used in herbal medicine as well as an ornamental plant in gardens.
Hedera helix L., commonly known as common ivy, is one of the few species ideal for air purification due to the resistance of urban pollution. This is a climbing plant that is very common in landscaping. Although it has a moderate ability to capture particles, by its volume it can capture more particles than any other small plant (Figure 4) (Sternberg *et al.,* 2010).

Figure 4. *Hedera helix* L. ground covering detail (https://www.dapplelandscapedesign.com.au/climbers/climbers/Hedera-helix-English-Ivy.htm)

The plant is a rampant, evergreen vine, commonly known as English ivy, European ivy, common ivy. It is a flowering plant species from the Araliaceae family.
Ivy grows up to 20-30 m in high where climbing surfaces, like trees, walls, pergolas, are available, but it also grows as a groundcover.

Common ivy is cultivated as an ornamental plant. There are multiple cultivars with different ornamental characteristics, such as variegated cultivars with yellow or white, or deeply lobed leaves, dwarf growth or with purple stems.
Although it is a species often used in landscaping, it is considered an invasive species, so more attention should be paid to maintenance.
Lavandula spp., or lavender, is an odoriferous plant that offers a fragrance to the environment. Its small leaves help to capture the particles from the air and reduce their dispersion (Figure 5) (Gabrys, 2018).

Figure 5. *Lavandula* spp. leaf details (https://garden.org/plants/photo/334136/)

Lavander is a species of flowering plant in the family Laminaceae (Șelaru, 2007).

Figure 6. *Salvia officinalis* L. leaves details (https://theoriginalgarden.com/p/seeds/aromatics_medicinals/aromatics_medicinals/seeds-salvia-officinalis-common-sage#gallery-4)

Salvia officinalis L., commonly named sage, is a bioaccumulative plant absorbing heavy metals such as zinc. Hairy leaves help to capture particles (Figure 6), and the flowers attract pollinators (Gabrys, 2018).
Other ideal plants for capturing particle matter with the help of leaves or the way of growing are *Cosmos bipinnatus* cvs. (garden cosmos), *Stachys byzantina* K. (lamb's-ear), *Cineraria maritima* L. (silver ragwort) and *Phalaris arundinacea* L. (reed canary grass).
Some tree and shrub species may also be used to improve air quality and absorb heavy metals.

Figure 7. Protective hedge and trees (http://gardendrum.com/2013/07/15/red-cow-farm-garden/

These may be used in plant compositions or to create protective walls (Gabrys, 2018) as seen in Figure 7. *Taxus baccata* L (yew) and *Pinus mugo* Turra (creeping pine), for example, help to capture the particles by having small leaves (Tatiana, 2009) and high resistance to dust, smoke and gas, while *Betula pendula* Roth. (silver birch), besides capturing particles and having a high resistance to smoke and gas (Tatiana, 2009), is also a bioaccumulator of heavy metals thus improving the quality of the soil (Beckett, 2000).

RESULTS AND DISCUSSIONS

Plants are living organisms that constantly feel and change our environment. There are plants that are much more efficient in taking pollutants, either by attracting heavy metals through their roots, or by channelling and depositing particles in the leaves or by absorbing gaseous pollutants through stomata (Gabrys, 2018).

Studies conducted by Imperial College (Shackleton *et al.,* 2010) have shown that vegetation hedges made from shrubs or perennials near pollution sources have reduced particle levels and contributed to the absorption of gases such as nitrogen dioxide.

Another study (Tremper *et al.,* 2015) shows how a protective curtain made of ivy reduced the level of pollution near a playground.

The study carried out by Säumel *et al.* (2012) indicated that high global traffic increases the content of heavy metals while the presence of barriers between the place of cultivation and roads decreases their content. The main protective curtains of urban crops are buildings and vegetation curtains (Säumel *et al.,* 2012).

Leake *et al.,* (2009) notes that although vegetable plants were grown on urban sites with high contamination, no evidence was found regarding the negative health effects when compared to typical urban sites. Thus, the study offers additional assurance that sites classified with high degree of contamination are not a major risk.

Growing one's own food in urban spaces has a possible health benefit thus improving the mental and psychological health of applicants (Leake *et al.,* 2009).

The most common pollutants in urban areas are anthropogenic (Vittori Antisare *et al.,* 2015). These are caused by the emissions of road traffic, incinerator, industrial deposits and the industrial history of the site (Chen *et al.,* 2005; Vittori Antisare *et al.,* 2015).

Intense human activity produces the main pollutant of the soil - heavy metals (Khan *et al.,* 2015). Studies on heavy metals have shown that the distance from contaminated roads or areas plays an important role in reducing the degree of contamination of plants (Gherardi *et al.,* 2009).

The place in the city where vegetables are grown influences the concentration of heavy metals in them. As an example, plants grown 10 m from the road have a higher concentration of heavy metals compared to plants grown at a distance of 60 m from the road (Vittori Antisari *et al.,* 2015).

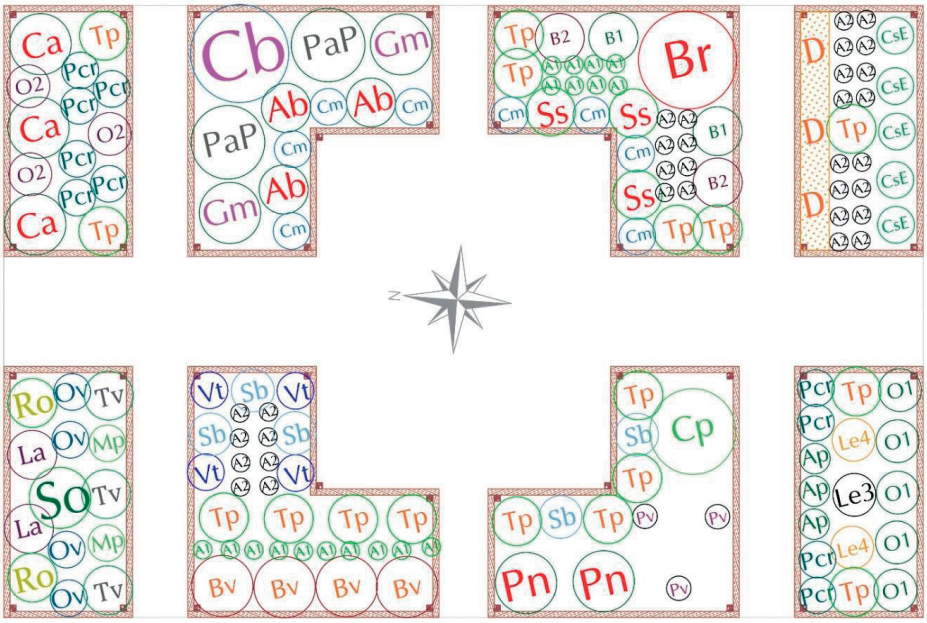

Figure 8. Example of planting plan

Plants that can reduce pollution or can be used as bioindicator of air pollution in urban areas are usually plants that have a surface where particulate matter can be trapped on (plants with hairy leaves) - *Alchemilla mollis* Rothm. (garden lady's mantle), *Euonymus japonicas* Thunb. (evergreen spindle), *Forsythia x intermedia* Sab. (border sorythia), *Hydrangea arborescens* L. (smooth hydrangea), *Parthenocissus quinquefolia* Planch. (Virginia creeper), *Parthenocissus tricuspidata* Planch. (Boston ivy), *Spiraea* spp. (spirea), *Salvia* spp. (sage), *Stachys byzantine* K. (lamb's-ear) etc. - or plants that are sensitive to some pollutants like ozone - *Phaseolus vulgaris* L. (common bean), *Artemisia* spp. (mugwort), *Festuca rubra* L. (red fescue), *Rhus typhina* L. (staghorn sumac), *Solanum tuberosum* L. (potato). etc (Gabrys, 2018).

As a result of this study, the following vegetable garden design was created, which can be seen in Figure 8.

The list of plants (Table 1) has been carefully made according to the ecological requirements of the plants (light, water, soil), their way of association and succession, the decorative elements (height, form, colour and texture of the leaves, flowers and fruits) and the possibility to decorate for a longer period of time.

Table 1. List of plants used in the planting plan

Abbreviation	Scientific name and cultivar	Common name
A1	*Allium sativum* L.	garlic
A2	*Allium schoenoprasum* L. cv. Chinese Chives	chives
Ab	*Aster novi-belgii* L. cv. Marie Ballard	New York aster Marie Ballard
Ap	*Apium graveolens* L. var. rapaceum	celery
B1	*Brassica oleracea* L. convar. acephala cv. Kadet	curly kale green Kadet
B2	*Brassica oleracea* L. convar. acephala cv. Scarlet	curly kale Scarlet
Br	*Brassica oleracea* L. var. capitata f. rubra	red cabbage
Bv	*Beta vulgaris* var. cicla cv. Chard Bright Lights	leaf beet Chard Bright Lights
Ca	*Capsicum annuum* L. cv. Brilliant	pepper Brilliant
Cb	*Cosmos bipinnatus* Cav. Cv. Sensation	garden cosmos Sensation
Cm	*Cineraria maritima* L.	silver ragwort
Cp	*Cucurbita pepo* L. cv. Óvári Fehér	Patison pumpkin
CsE	*Cucumis sativus* L. cv. Ekol	cucumber Ekol
D	*Daucus carota* L. cv. Rondo	carrot Rondo
Gm	*Geranium maculatum* L. cv. Splish Splash	wild geranium Splish Splash
La	*Lavandula x intermedia* L. cv. Grosso	lavender Grosso
Le3	*Lycopersicon esculentum* Mill.	tomato
Le4	*Lycopersicon esculentum* Mill. cv. Yellow Pearshaped	cherry tomato Yellow Pearshaped
Mp	*Mentha x piperita* L.	peppermint
O1	*Ocimum basilicum* L. cv. Italiano classico Genovese	basil Italiano classico
O2	*Ocimum basilicum* L. cv. Serafim	basil Serafim
Ov	*Origanum vulgare* L.	oregano
PaP	*Phalaris arundinacea* Picta	reed canary grass
Pcr	*Petroselinum crispum* Mill.	parsley
Pn	*Phaseolus vulgaris* conv. nanus L. cv. Lingua di Fuoco Nano	dwarf bean Lingua di Fuoco Nano
Pv	*Phaseolus vulgaris* L. cv. A Cosse Violette	bean A Cosse Violette
Sb	*Stachys byzantina* K.	lamb's-ear
So	*Salvia officinalis* L.	sage
Ss	*Salvia splendens* Raf. cv. Scarlet	scarlet sage
Tp	*Tagetes patula* L.	French marigold
Tv	*Thymus vulgaris* L.	common thyme
Vt	*Viola tricolor* L.	Johnny Jump up

CONCLUSIONS

The main pollution sources in urban and peri-urban areas are anthropogenic. These are caused by incinerators, industrial deposits, industrial history of the site and mainly, from the emissions of road traffic. The contaminants that are stored in water, soil and air can affect

the product quality and healthiness of the plants but can also threaten the health of the people.

Plants have the ability to change our environment. There are plants that have a high resistance to urban pollution and are more efficient in capturing pollutants throughout their roots, stomata or depositing particles on the leaves.

In order to create an environmentally friendly vegetable garden some aspects were taken into consideration. It is best to have a location far away from a high traffic main road but this aspect is not always met. The main protective barrier of a private garden consists of a green hedge. To enhance the ability of capturing more particle matter it is recommended to plant trees that can have also the ability to capture air and soil pollutants (for example silver birch).

Different plant species have different abilities to absorb and accumulate metals thus, two species of plants grown in the same soil do not present the same risk to human consumers.

Another way to reduce pollution in a small vegetable garden is to take advantage of companion planting and integrate species of plants that are capable of attracting particle matter with their leaves (e.g. *Stachys byzantina* K.*, Cineraria maritima* L.) or have the ability to absorb heavy metals from the soil (e.g. *Salvia officinalis* L., *Aster* spp.).

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