UNIVERSIDADE D COIMBRA

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Citizens' perceptions on weeds and their control using synthetic chemical herbicides

Dissertação no âmbito do Mestrado de Biodiversidade e Biotecnologia Vegetal orientada pela Professora Doutora Paula Cristina de Oliveira Castro e Professora Doutora Cristina Isabel Cabral Galhano e apresentada ao Departamento de Ciências da Vida da Faculdade de Ciências e Tecnologia da Universidade de Coimbra

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Resumo

Nos últimos anos, a preocupação com a libertação de herbicidas sintéticos no meio ambiente tem vindo a crescer na opinião pública, especialmente com o estabelecimento cada vez mais evidente dos impactes ambientais e na saúde humana. Assim, o controlo de infestantes com recurso a herbicidas sintéticos é considerado cada vez mais um problema global, não só na agricultura, mas em todos os ecossistemas, incluindo as áreas urbanas. No entanto, existem poucos estudos científicos abrangendo as perceções da população em geral sobre os impactes destes produtos, e os que existem, incidem principalmente em profissionais ligados à sua utilização, sobre a perceção dos riscos dos herbicidas, assim como sobre os métodos utilizados no seu controlo. Para colmatar esta falta de informação, foi realizado um inquérito online para avaliar as perceções da população portuguesa sobre: a existência de plantas infestantes e o respetivo controlo nas suas áreas de residência; o uso de herbicidas químicos de síntese ou de alternativas, assim como sobre a sensibilidade acerca dos impactes na saúde humana e no meio ambiente e o seu interesse nesta temática. Demonstrou-se que existe um grande interesse no tema, sendo dada maior importância à necessidade de controlo de plantas infestantes em áreas funcionais como por exemplo, passeios e muros. A maioria da população refere conhecer o composto glifosato e os seus efeitos secundários, defendendo a redução ou proibição da aplicação dos químicos de síntese em áreas urbanas. Os herbicidas são amplamente reconhecidos como perigosos para a saúde e para o ambiente; os respondentes referem ainda que a informação sobre ações de controlo em espaços públicos é escassa. No entanto, existem diferenças de perceção entre grupo de respondentes, dependendo do seu local de residência, género, idade e terem formação na área do ambiente/ecologia. Os resultados obtidos reforçam a necessidade de existirem mais estudos, mais sensibilização e informação acerca do controlo de infestantes, bem como a inclusão das populações na procura de alternativas aos herbicidas químicos de síntese.

Palavras-chave: Perceções da população, herbicidas, glifosato, controlo de plantas infestantes, áreas urbanas, inquérito por questionário, impactes na saúde e meio ambiente.

Abstract

Weed control using synthetic herbicides is considered a major problem not only for agriculture but also for urban areas. However, there are few scientific studies, covering the general population, focusing on citizens' perception about the presence of weeds, as well as on the methods used to control them, particularly on the use of synthetic chemical herbicides. In recent years, concern about the release of synthetic herbicides into the environment has been increasing in public opinion, especially with the increasingly evident establishment of environmental and health impacts. Thus, weed control using synthetic herbicides is increasingly seen as a global problem, not only in agriculture but in all ecosystems, including urban areas. However, there are few scientific studies covering the perception of impacts by the general population, and when they do exist, focus mainly on professionals involved in their use, on the perceived risks of herbicides as well as on the methods used to control them. To make up for this lack of information, an online survey was carried out to assess the perceptions of the Portuguese population on: the existence of weeds and their control in the areas of residence; the use of synthetic chemical herbicides or alternatives, as well as the sensitivity about the impacts on human health and the environment; interest in the topic of environmental education and participation in related initiatives. It has been shown that there is a great interest in the theme, with greater importance being given to the need for weed control in functional areas such as pavements, walls). It appears that the majority of the population is aware of glyphosate and its side effects and advocates the reduction or banning of synthetic chemicals in urban areas. Herbicides are widely recognized as hazardous to health and to the environment and knowledge about control actions in public spaces is scarce. Nevertheless, there are differences in perception between groups, depending on the place of residence, gender, age, and training in the environment area. The obtained results reinforce the need for more studies, greater transparency and information on weed control, as well as the inclusion of populations in the search for solutions.

Key-words: Population perceptions, herbicides, glyphosate, weed control, urban areas, questionnaire survey, health and environmental impacts.

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2,4-D: 2,4-Dichlorophenoxyacetic acid

ABE: Academic background in environmental area or ecology

ALS: Amyotrophic lateral sclerosis

AMPA: α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid

AMU: Área mediamente urbana - Medium Urban Area

APR: Área predominantemente rural - Predominantly rural área

APU: Área predominantemente urbana - Predominantly urban area

DEFRA: Department for Environment, Food and Rural Affairs

DGAV: Direção-Geral de Alimentação e Veterinária - General Directorate of Food and Veterinary

DGT: Direção-Geral do Território - General Directorate of territory

DNA: Deoxyribonucleic acid

DRAP: Direção regional de agricultura e pescas - Regional directorate of agriculture and fisheries

EC: European commission

EEC: Electric conductivity

eNGO: Environmental non-governmental organization

FAO: Food and Agriculture Organization

IARC: International Agency for Research on Cancer

INE: Instituto Nacional de Estatística - National Statistical Institute

LAU: Local Administrative Units

miRNA: microRNA

NUTS: Nomenclature of Territorial Units for Statistics

PANUSPF: Plano de Ação Nacional para o Uso Sustentável dos Produtos Fitofarmacêuticos - National Action Plan for the Sustainable Use of Plant Protection Products

PGS: Public green space

RTP: Retrato Territorial português - Portuguese territorial portrait

TIPAU: Tipologia de áreas urbanas - Typology of urban areas

UN: United Nations

WHO: World Health Organization

1. Introduction

In 2018, more than half of the world population (55.3%) was concentrated in urban areas, the main habitat of our species, but significantly different from those from which we evolved over 100,000 years ago in Africa, characterized by forests, grasslands and savannas. However, the conditions needed to live in a healthy and sustainable way are the same (Douglas & James, 2015; UN DESA 2018). The impacts caused by humans, mainly resulting from the characteristic economic activities of our species, such as agriculture and industry, are global and affect all terrestrial and aquatic ecosystems. The level of each environmental impact varies in severity and interconnection of the different systems affected, causing local, regional and even global effects. Environmental impacts such as water and soil pollution, destruction of vegetation cover, and other localized disturbances, are often related with the presence of a higher population density and anthropogenic activities (Steffen et al., 2015). In fact, there is a deep human intervention in vast areas, completely changing the soil and the vegetation cover (Salomons 1994; Douglas & James, 2015).

Cities, the economic drivers of our civilizations and the center of our cultural life, are one of the most affected areas (Barrico & Castro, 2016). These are areas with high levels of pollution caused by humans, with the release of pollutants in gaseous, liquid or solid form that lead to the destruction or degradation of ecosystems, habitats, and to a drastic reduction in biodiversity (Steffen et al., 2015; Barrico & Castro, 2016). In fact, urbanization is one of the greatest threats to biodiversity worldwide (MacDonald et al., 2013). Current management practices of these spaces often negatively affect biodiversity, through the maintenance of lawns, destruction of habitats, simplification of habitats, and use of pesticides (McDonald et al., 2019). Nevertheless, urbanization can also play a significant role in biodiversity conservation, if good management and planning of the present green spaces and weed control are conducted (Lambert & Donihue, 2020).

Despite the severity of the environmental impacts, the biodiversity in cities can be significant, both for native and exotic species. It is possible to observe the existence of vegetation covering different areas, such as green areas, vacant areas, humid areas, land and abandoned buildings. In open gardens we can find numerous spontaneous plant species, many of which often seen as weeds, supporting several ecosystems relevant to the quality of life in cities (Douglas & James, 2015; Francis et al., 2016).

The control of weeds in urban environments is one of the biggest challenges for the quality of life in these areas, since their control is traditionally carried out using herbicides, with severe impacts on population health and well-being, but also on urban ecosystems themselves and those around them (Stuart et al, 2012; MacCance et al., 2018).

Currently, there is a broad consensus that pesticides have considerable negative impacts on health and on ecosystems (Coppin et al., 2002; MacLeod et al, 2010; Ríos-González et al., 2013; Vazquez et al., 2017). Many of them have been found to be toxic, carcinogenic, endocrine disrupting or mutagenic, for some or most living beings in different environments. Its polluting action is mainly due to factors that can be controlled, such as its overuse or misuse. The advance of technical knowledge, as well as its disclosure through the general population, has led to the development of greater awareness about the problem and to the change in established practices (Kristoffersen et al., 2008; MacLeod et al, 2010).

This work seeks to study the population's perceptions on: the presence of weeds in their areas of residence, their control and used methods, particularly, to the use of synthetic chemical herbicides, and on the importance of this topic. It also aims to correlate those perceptions with the asymmetries existing in the population, such as the degree of urbanization, gender, level of education, age or background on environmental areas or ecology.

This dissertation is divided into five chapters.

In Chapter 1, *Introduction,* divided into two parts: *Weeds in urban areas, ecology, control, and health impacts*, a theoretical framework of the theme covered in the dissertation is given. Urban areas are characterized, it is described the concept of weeds and their ecology. It also gives information on the methods used to control weeds and on the main related regulation. And, *Perceptions and behaviors to the use of pesticides*, a state of the art on the populations' perceptions of the presence of weeds, their importance, control, the use of herbicides, and their impacts on health and on the environment, is presented.

Chapter 2, *Material and methods,* explains the methodological approach, the structure of the questionnaire and how it was made available to the population.

Chapter 3, *Results,* characterizes the surveyed sample and the overall results of the questionnaire.

Chapter 4, *Discussion and conclusion*, offers an analysis and discussion of the results obtained in this study, compares them with the literature on the addressed subjects and draws an overall conclusion.

Chapter 5, *References*, bibliographical references are cited.

1.1. Weeds in urban areas, ecology, control, and health impacts

1.1.1. Weeds, definitions, and characteristics

There are several definitions for weeds, which are deeply rooted in different human cultures, varying depending on the native language (Zimdahl, 2007). Weeds are considered as plants that grow where they are not wanted (Britannica, 2020; Figure 1). They can also be considered as any plant that interferes with the activities or objectives of humans (Humburg, 1989) or as any plant or vegetation, excluding fungus, that interferes with people's goals or requirements (EWRS, 1986). From an agricultural point of view, weeds corresponds to all plants that reduce crop productivity. In urban environments, the classification of plants as unwanted can be related to the usefulness of the land or to aesthetic concepts. Thus, it can be concluded that the term weed plant is a broad, complex term, and subject to different types of interpretation, depending on the attitude towards the question (Zimdahl, 2007).

Figure 1: Weeds at the edge of a pedestrian walk.

Weeds are therefore plants unwanted by humans in a particular location. It is not possible to establish any specific ecological or scientific criteria for their classification as such. However, it is possible to establish some common characteristics depending on the context in which they are found, such as agricultural systems, urban wasteland, or land used for ornamental purposes (Zimdahl, 2007). From the diversity point of view, these plants represent a continuity with the regional characteristic flora of each ecosystem (Douglas & James, 2015).

The main characteristic shared by most weeds is their ability to grow in disturbed habitats, but some of the following characteristics can also be found (Baker, 1974; Zimdahl R. L. (2007)):

- Ability to quickly produce seeds, while plants are still young and in basal zone.
- Rapid growth and maturation.
- Different ways of reproduction, by seeds and vegetatively.
- Ability to survive in a wide range of environmental conditions.
- Self-pollination is often possible. If pollination is mandatory, it is not specialized.

- Seeds resistant to long periods of dormancy, not requiring specific conditions for germination.
- Small-sized seeds, difficult to recognize, easily confused with crop seeds in agricultural ecosystems. They are produced throughout the year, whenever possible and in high quantities.
- The roots can be extensive and deeply buried; they can also have a high capacity to preserve nutrients.
- Vegetative organs are able to regenerate quickly.
- Resistance to predation, some with the presence of thorns, unpleasant taste or odour.
- They are very competitive in terms of nutrition, light or water.
- They arise spontaneously.
- They are resistant to various control methods and often to herbicides.

All of these characteristics demonstrate a special adaptation to human managed ecosystems, as weeds have a short life cycle, after control or disturbance (Baker, 1974).

Figure 2: Arundo donax in an urban context

In urban environments of the central region of Portugal, namely Leiria or Coimbra, we may often find some of the following species: *Daucus carota* L. subsp*. azoricus, Picris echioides* L.*, Piptatherum miliaceum* subsp*. miliaceum, Hirschfeldia incana* (L.) Lagr.-Foss.*, Stipa gigantea, Achillea ageratum, Conyza* spp.*,* E. Walker (exotic)*, Foeniculum vulgare* Mill*., Dittrichia viscosa, Digitaria sanguinalis* (L.) Scop. (exotic)*, Arundo donax* (Invasive)(Figure 2).

1.1.2. Urban ecology

From a purely ecological point of view, urban ecology seeks to understand the complex relationships among and within biological communities in an urban context. The size and density of urban centres are critical for the transition between the rural and urban spaces. The larger the urban centre, the greater the change in biodiversity and ecology on a regional scale (Aronson et al., 2014; Douglas & James, 2015; Francis et al., 2016).


Figure 3: Leiria's urban landscape.

Urban environment offers numerous ecological niches, each with its own specificities and with species adapted to them (Figure 3). Cities are "islands" of heat, with temperatures higher than the regions that surround them, consequently, the frequency of C4 plants increases. On the ground, especially in paved or covered areas, an arid environment, favour the presence of xerophytes (Benvenuti, 2004). Pedestrians or vehicles often circulate in urban areas, treading the plants, also conditioning the present species. Plants with meristems at the base of the stem show better resistance to trampling, being also more resistant to control methods, allowing their growth on pedestrian walks, for example. We can highlight the abundance of the families *Poaceae*, *Plantaginaceae*, and *Asteraceae* which include some species with these characteristics. On the sidewalks, and uncultivated land, plants with more exposed meristems can appear. Perennial plants are particularly well adapted to the urban environment, combining vegetative propagation and the presence of meristems below the surface (Benvenuti, 2004).

From a land and soil organisation perspective, one of the most evident contrasts between the urban and agricultural environment is their occupation. In urban areas, the soil is often covered with artificial infrastructures with different purposes, often sealing the soil (Benvenuti, 2004). From a biological point of view, the occupation of the soil can be divided into two main groups, artificial and non-artificial soils (DGT, 2014). As noted earlier, artificial soils are occupied by buildings, constructions, or simply paved rooftops, while the rest are "uncovered", facilitating the survival of vegetation. Thus, different coverage of the urban area can be distinguished as follows (Benvenuti, 2004):
- Built area for housing, industry or services;
- Hard surfaces like roads, sidewalks and other paved surfaces;
- Gardens, separators, roundabouts and other areas with soil covered by vegetation;
- Woods, wasteland;
- Bare soil, without vegetation.

The preservation of intact original areas in the form of gardens or forests positively affects the diversity of plant species that live in urban and surrounding areas. The increasing of the vegetation covered area will have very positive impacts on the urban fauna and flora, sustaining and preserving regional biodiversity (Aronson et al., 2014; Barrico & Castro, 2016).

Despite the urban environment hindering the development of plants, ecological succession naturally continues to put pressure on land and buildings, with the emergence of species adapted to the harsh existing conditions inherent to this environment (Benvenuti, 2004). The presence of paved surfaces limits, but does not exclude, the presence of fauna and flora. Even in heavily urbanized areas, the existence or appearance of open spaces, fractures or sediment accumulation allows the emergence of numerous micro-habitats, quickly colonized by more adapted species. In these areas, we can also find different spots / gardens, artificially maintained and occupied by different plant species. There are also spaces with unpaved surfaces, such as vacant lots and separators of communication routes, often occupied by spontaneous vegetation (Douglas & James, 2015).

Hard surfaces, such as walls and paved surfaces, can be occupied by lichens, mosses and other rootless photosynthetic organisms. Other paved surfaces with cracks and fractures allow the accumulation of sediments, and more complex species with root systems may be found (Figure 4). Mainly ornamental and exotic plants can be found in pots, flowerbeds and gardens (Douglas & James, 2015).

Figure 4: Weeds in sediments, pavement gaps and sidewalks.

In public gardens, we can find vast lawns, surrounded by trees and ornamental plants. In these spaces, it is common to find exotic species. We can therefore find areas of monoculture, with low biodiversity alternating with enormous diversity. The beds are inserted in these created habitats and maintained artificially (Douglas & James, 2015).

In cities it is also common to find wetlands, being a biodiversity hotspot. In these places, more native species are expected to be found. It is also possible to find traces of the original green spots, with more native species (Figure 5), representing the continuity of ecosystems surrounding urban areas (Douglas & James, 2015).

Finally, there are abandoned or vacant lots, places that have suffered a major disturbance, at a certain time, with complete alteration of the vegetation cover. However, when abandonment occurs, the process of ecological succession can be restarted, leading to a certain degree of regeneration. In this type of ecosystem, the vegetation can be very diverse (Douglas & James, 2015).

Urban ecosystems can withstand a high animal diversity, domestic and wild. These may have been introduced or present a continuity with the regional fauna (Douglas & James, 2015). The presence of birds depends directly on the vegetation mantle. The larger the area covered by vegetation, the less the impact on these populations (Aronson et al., 2014). The control of plant weeds in an urban environment reduces the population of native birds. On the other hand, the creation of green spaces with larger plants benefits these group pf organisms (Archibald et al., 2017).

Figure 5: Traces of regional flora composed of indigenous species in an urban context.

In hard surfaces, the critical points for the appearance of plants are cracks, as well as areas of separation of the different coverings, allowing access to the soil below (Benvenuti, 2004; Rask & Kristoffersen, 2007). The accumulation of waste or sediments on covered surfaces can also lead to the development of undesirable plants. In cities, unwanted plants may also grow on curbs, separators or vacant lots. When germinating and developing, plant weeds can be very harmful to populations and present some risks, namely (Rask & Kristoffersen, 2007):

- They cause damage to the surrounding surfaces and buildings, increasing the size of fractures and cracks, reducing its usefulness and life span.

- They can cause accidents on the communication routes, due to lack of visibility, damaging the road or making the floor more slippery.

- They cause more waste to accumulate, allowing the development of larger weeds.

Furthermore, a part of the population considerers important the control of some visually undesirable plants, which can be considered a sign of decline (Benvenuti, 2004, Rask & Kristoffersen, 2007).

The dynamics of colonized urban areas by vegetation is extremely variable and is enormously dependent on micro-ecosystems and disturbances created by anthropological action. The extent and composition of urban flora may be an indicator of environmental impact and ecosystem quality. Nevertheless, the existence of isolated plants or green patches, is essential for the preservation of biodiversity contributing to the provision of ecological services, such as pollination or maintenance of animal life, as well as to the human well-being (Benvenuti, 2004). It is therefore necessary to reconcile the conservation of maximum biodiversity, eliminate invasive species, control unwanted plants only when they become harmful or dangerous for our life in society, and eliminate the use of herbicides in urban areas (Benvenuti, 2004; Rask & Kristoffersen, 2007; DEFRA, 2015; Aronson et al., 2017). Controlling plants just because they are visually unpleasant is an unnecessary expenditure of resources, apart from destroying living beings essential for the maintenance of healthier and more diverse urban ecosystems (Rask & Kristoffersen, 2007).

1.1.3. Herbicides, and weed control

Figure 6: Herbicide manual spraying.

The advancement of knowledge in ecology and health areas has questioned the use of agrochemicals (Figure 6). The awareness of the population and decision makers about this problem has placed this issue as one of the public health priorities in an urban environment, creating a new debate on the use of pesticides on a large scale, and more specifically of herbicides in urban environments (Rask & Kristoffersen, 2007).

The specificities of the urban environment, make the application of plant protection products in this area different from that in agricultural ecosystems. Flora characteristics, the available techniques, and the challenges generated by the specificities of cities have to be taken into account (Sahin, 2019).

One of the environmental challenges for land use in urban areas is the drainage of rainwater. Impermeable soils prevent water from penetrating the soil creating drainage alternatives to nearby watercourses. Thus, the pollution generated by the herbicides used in weed control is concentrated in some spots and taken to aquifers, contaminating them and amplifying the impact of plant protection products on the surrounding ecosystems. This contamination can have an impact on the quality of consumed water in cities and even make the water unfit for consumption (Skark et al., 2004).

There are other issues that should be considered regarding weed control in urban areas. Unlike to what happens in agricultural areas, in urban areas, there is no need to consider the herbicide susceptibility of crop species in the intervened areas. This issue made the use of herbicides much more practical (Rask & Kristoffersen, 2007). Nevertheless, the space available for the use of heavy machinery is a difficulty challenge in the urban environment, conditioning the tools available for weed control. Urban infrastructures, the presence of parked cars or trees are some of the conditions for the limited space available in our cities (DEFRA, 2015).

Control plans are essential to reduce costs, to optimize existing human and mechanical resources, and to follow all legal regulations (Rask et al., 2013). These are designed to assist decision makers and stakeholders in the control of unwanted plants, to follow all the best practices and recommendations mentioned above. Due to the complexity of the existing legislation, and the high level of demand in choosing the most appropriate alternatives for weeds control, the development of a treatment plan is only available to large institutions and resources (DEFRA, 2015). In Portugal, the responsibility for controlling weeds in urban areas lies on local government bodies, such as municipalities and parish councils. There are also large companies that need to manage vast areas of land with weed problems, such as highway concessionaires. The legislation is also applied to companies contracted to implement the weed control plans. Three different plans can be distinguished (DEFRA, 2015): control with chemical herbicides, integrated control, or control without chemicals. Current European legislation, Regulation (EC) No 1107/2009 lays down rules for the authorisation of plant protection products in commercial form and for their placing on the market, use and control within the Community.

Techniques for controlling weeds without synthetic chemicals are divided mainly in two groups: through heat and mechanical techniques. However, they also have disadvantages in terms of pollutant gas emissions, costs and effectiveness (Rask & Kristoffersen, 2007). In fact, they require more detailed monitoring and more frequent control actions than chemical option. While herbicides affect the plant as a whole, alternative techniques affect only the upper part, increasing the speed of regeneration (Benvenuti, 2004).

Heat treatments can be divided into three distinct groups, based on their means of action: direct or indirect heating, and freezing. Direct heating includes flame, infrared, hot water, hot air, and steam techniques. Indirect heating comprises electrocution, microwave, laser, and ultraviolet. The third group contains all the freezing techniques. The mechanical control can be divided by size and automation, ranging from the manual mechanical means, the automated mechanical operated, and transported by an operator, and the heavy mechanical transported by a vehicle (Rask & Kristoffersen, 2007; Sahin, 2019).

In the early 20th century, the emergence of the modern chemical industry and agriculture was accompanied by the development of many products aimed at improving the yield of crops as, fertilizers, pesticides, herbicides, among others (MacLeod et al, 2010). As a result of the period in which they were developed, most of these products are of chemical origin, with research and development of new and better plant protection products based on plant extracts being left aside. We may even have missed an excellent opportunity to study the empirical knowledge acquired over time. The development of new pesticides for agriculture started to be used to control weeds in all areas occupied by man (Nicolopoulou-Stamati et al., 2016). The importance and interconnection between environmental preservation, pollution and health has become clearer, too. Thus, it has become evident that most of the pesticides have very negative impacts on human health and ecosystems (MacLeod et al, 2010; Mostafalou & Abdollahi, 2013; Nicolopoulou-Stamati et al., 2016). Its polluting action is mainly due to factors as its overuse or misuse, which should be reduced. Since pesticides are still widely used, legislation has acted to gradually restrict or ban their use (Kristoffersen et al., 2008). The most toxic products have been gradually withdrawn from circulation, while others have seen their application limited to less populated areas, namely the agricultural area (MacLeod et al, 2010). There have also been drastic changes in its application, both in personal protection measures required for people that operates with pesticides, as well as in the used tools. Areas where toxic products have been used are often isolated (Kristoffersen et al., 2008).

A solution to reduce herbicide use may be to change behaviours and aesthetic standards, namely by tolerating more unwanted plants, and reducing their control to the strictly necessary, that is, for reasons of use and safety. Sensitizing and educating population can be crucial for changing aesthetic standards (Zimdahl, 2007; Kristoffersen et al., 2008).

1.1.4. Herbicides

1.1.4.1. Definition and legislation

The concern with the application of plant protection products is neither new nor recent. The first legislation on the subject in Portugal dates back to 1940, through Decree No. 30270, being regularly reviewed and updated, as science and the perception of the population evolves.

With the integration of Portugal in the European Union, we have witnessed an increasing homogenization of the legislation of the different member states. It appears that the environmental legislation regarding the release of chemical compounds into the environment has evolved to restrict the use of products with the greatest impacts on human health and natural ecosystems (MacLeod et al, 2010).

The legislation distinguishes two groups of compounds, plant protection products and biocides. From a legal point of view, Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 regulates the placing of plant protection products on the market. In Portugal, its regulation and inspection are carried out by DGAV (Direção-Geral da Alimentação e Veterinária [General Directorate of Food and Veterinary Office]).

Regulation (EC) No. 1107/2009 and subsequent amendments defines plant protection products in the European area and consequently in national territory, through Article No. 2. Phytopharmaceutical are products that contain or consist of active substances, phytotoxicity protectors or synergistic agents that are intended to:

- Protection of plants or plant products against harmful organisms, or prevention of these organisms, except products used for hygiene and non-protection.

- Influential vital processes of vegetables, other than nutrients.

- Conservation of plant products, not included in the specific legislation on preservatives.

- Destruction of undesirable plants or plant parts, except algae.

- Limit or prevent undesirable growth of vegetables.

Directive 2009/128/EC defines the framework for action on the sustainable use of pesticides with the objective to reduce the harmful effects on human health and the environment caused by plant protection products use. It also intends to favour the use of non-chemical products or alternative techniques to the use of products of chemical origin, whenever possible.

The Portuguese Law No. 26/2013, of April 11, results from the transposition of the Directive 2009/128/EC. This legislation aims to regulate the activities of distribution, sale and application of plant protection products in the national territory. One of the most comprehensive measures of this law was the obligation to attend training courses for the first time, by all agents involved in the sale and application of these products, creating the figure of certified applicators.

There is also the National Action Plan for the Sustainable Use of Plant Protection Products, approved by Portaria nº 82/2019, of 20 March, of the Ministries of the Environment and Energy Transition and of Agriculture, Forests and Rural Development. This plan aims to strengthen preventive crop protection measures, increasing protection and integrated production practices, promoting innovative and competitive agriculture and forestry that helps to keep rural populations in place, generates employment and, at the same time, protects natural environments, waters and the diversity of fauna and flora.

1.1.4.2. History and production of herbicides

The use of substances defined as pesticides has been known since antiquity. The substances used were of natural origin and consisted of extracts of natural origin. From the 1870s, products of inorganic origin began to be used. After 1945 the first organic compounds were synthesized. Within the main groups of pesticides, the consumption of herbicides gained prominence in the 1990s, when it surpassed the remaining compounds and started to represent 47.5% of the pesticides sold (Zhang et al., 2011). In 1940, the first modern herbicide, 2,4-D, was discovered in a biological warfare program (Jarman & Ballschmiter, 2012). Glyphosate was first synthesized in 1950, but only in 1970 was identified as an herbicide. Its commercialization started in 1974 by Monsato®, under the commercial name Roundup (Benbrook, 2016).

Since the appearance of the first herbicides, safety issues regarding their use have been present and have been listed for substances by levels of toxicity (WHO, 2018). Particularly dangerous substances, that is, those with high levels of toxicity, were withdrawn from the market (WHO, 2019). Other substances continue to be allowed, sometimes with doubts as to their real long-term impacts and need more research or independent research (Corsini et al., 2013; Myers et al., 2016; Nicolopoulou-Stamati et al., 2016; Tarazona et al., 2017; Van Bruggen et al., 2018; Gillezeau et al., 2019). One of the most popular substances is glyphosate, mainly because it is the most used compound globally (IARC, 2015). Presently there are about 500 authorized compounds mass produced and distributed (Zhang et al., 2011). Their release into the environment always presents a potential risk of environmental impact, since they are all, at least slightly toxic (Jurado et al., 2011).

1.1.4.3. Pesticides impact in nature and health

Pesticide used in plants, whether intended for agriculture or ornamental, always implies the release of active compounds into the different systems. The way and the speed of propagation depends on the application method. Spraying and/or dissolving solid products in waters present greater risks for the balance of ecosystems, since entering the water cycle, these compounds will tend to propagate in all hydrological systems and eventually spread throughout the biosphere (Jurado et al., 2011). Spraying these substances in adverse weather conditions, such as wind or heavy rain, also contributes to the greater and faster spread of the pollutants (Schwarzenbach et al., 2010).

Herbicides, like any other chemical product, once present in the environment, may continue in their original chemical formula, or be degraded into new by-products, with changes in bioavailability or toxicity. Controlling the presence of these by-products is also important to establish contamination criteria (Schwarzenbach et al., 2010).

Once present in the environment, herbicides will behave like other pollutants (Zhang et al., 2011; Hosseini Bai & Ogbourne, 2016). Some will be retained on the surface in insoluble or soluble forms, others will infiltrate the soil (Nabais et al., 2007; Hosseini Baie & Ogbourne, 2016). In the soil, pollutants can be adsorbed to the liquid phase of the soil, others will simply enter together with other soil compounds (Hosseini Baie & Ogbourne, 2016). Those that enter the water cycle, either through runoff or leaching, or because they are already dissolved, will enter and follow the water courses, either superficial or underground, and may end up with impermeable underground aquifers or go on to other places and reaching the oceans last (Schwarzenbach et al., 2010; Jurado et al., 2011). The ability to leach depends on the characteristics of the soil, terrain topology, meteorology and lastly, and not less importantly, the specificities of the product (Lefrancq et al., 2017).

In urban environments, where the soil is widely covered by impermeable surfaces, runoff waters will tend to accumulate higher concentrations of herbicides (Schwarzenbach et al., 2010).

As long as they are present in the biosphere, whether immobilized or transitory, these chemical compounds can be bioavailable for different living beings (Zhang et al., 2011). Depending on the chemical, there are different ways to enter the food chains. The first will be direct absorption when spraying and/or placing herbicides. Animals can ingest directly, undergo skin absorption and/or respiratory absorption, depending on the species in question (Jurado et al., 2011). As for plants, they will be able to absorb the product through aerial contact or through root absorption once present in soil and water (Van Bruggen et al., 2018).

In all these cases, either through the autotrophic beings that occupy the basal places of the food chains, or through direct or indirect consumers, the pollutants will enter the food chain and may present different levels of bioaccumulation (Van Bruggen et al., 2018). Each compound has different characteristics and different capacities to be eliminated from the bodies, varying from species to species, since each organism has different cellular/body excretion mechanisms. These products can thus accumulate. Bioaccumulation is the process of the concentration increasing of chemical products along the trophic chains in the organisms, through the direct or indirect ingestion (contaminated food) of the compounds, without them being able to eliminate them. In short, the bioaccumulation of chemical compounds presents increased environmental, animal and human health risks, as it worsens over time. In the case of humans, we are particularly vulnerable because we are the top predator in food chains, with a relatively long-life span, leading our bodies to bioaccumulate throughout our lives (Mackay & Fraser, 2000; Chopra et al., 2011).

Traces of herbicides can be found in soil, surface water, and groundwater (Nabais et al., 2007; Schwarzenbach et al., 2010; Van Bruggen et al., 2018). They can also be found in microorganisms, algae, plants, fungi, microscopic and macroscopic animals, domestic animals and humans (Van Bruggen et al., 2018). Glyphosate residues can also be found in products for human consumption (Hosseini Baie & Ogbourne, 2016).

Synthetic chemical herbicides, whether certified as biological or not, are therefore considered environmental pollutants and are covered by the UN Sustainable Development Goals goal, through the reduction or elimination of dangerous chemical substances (WHO, 2019; UN, 2020).

As we have already seen, the impact of herbicides exists in all systems of the biosphere (Schwarzenbach et al., 2010; Van Bruggen et al., 2018). The impacts of herbicides on the environment can be direct or indirect. Direct impacts are the effects and damages caused directly to an individual, species or community, while indirect paths are the effects observed in consumer populations. Laboratory tests focusing only on a single species under study are hardly representative of the impacts on a given ecosystem or biome, due to the diversity of species present (Jurado et al., 2011).

The presence of pesticides is directly related to the loss of biodiversity (Kleijn & Sutherland, 2003). Some herbicides can act as fungicides. In general, in non-target plants, herbicides reduce growth, seed production and the competitiveness of susceptible or sensitive plants (Jurado et al., 2011). Tests on toxicity in invertebrates have shown that there are few direct effects and that the loss of biodiversity is mainly due to the destruction of habitats, through the application of herbicides. There is laboratory and field evidence that the fertility of the invertebrate population is affected by herbicides (Marshall et al., 2001).

Herbicides spraying can alter the nitrogen cycle, reducing the amount of nitrogen available to plants and crops, affecting intermediate microorganisms. Some herbicides have the ability to directly alter the metabolism of plants affected by the herbicide, reducing the absorption of this nutrient. Depending on different factors, the application of herbicides can change the rate of nitrogen mineralization/immobilization in the soil (Jurado et al., 2011).

One of the most visible impacts of pesticides, including herbicides, is on pollinators. This is particularly economically important, since these organisms provide an essential service for our agriculture production (Mullin et al., 2010). One reason pointed for the rapid decline in the number of bees (i.e. *Apis mellifera*) and other pollinators is the toxicity of pesticides (Mullin et al., 2010; Ostiguy et al., 2019).

The impact of herbicides in human health can be divided into two categories, chronic or acute disease. Poisonings can also be divided into two different types: occupational, derived from work and with direct handling, and environmental, derived from accidental poisoning, such as through food, accidental exposure, or ingestion. There are indications that accidental poisonings are less worrying than occupational ones (Parrón et al., 2014). The formulation of herbicides will dramatically alter their effects and toxicology (Mesnage et al., 2019). Each product must be studied individually, not only regarding the active substance, but for the final formulation, since it will completely change its characteristics, especially for toxicological effects (Mesnage & Antoniou, 2018). Exposure to pesticides can occur in different ways and will influence the effects on the body. Exposure can occur through the following organs: through the skin, respiratory organs, ocular and oral ingestion (Kim et al., 2016).

One of the generic effects caused by pesticides is to trigger epigenetic mechanisms, which can result in a harmful effect on human health (Collotta et al., 2013; Mostafalou & Abdollahi, 2013). The damage can be caused directly in the DNA, causing mutagenic damage, or chromosomal aberrations. In the case of mutagenic damage, errors can occur in the insertion of the nitrogenous base, adduction of DNA, break of the double helix or break of just one of the helices (Mostafalou & Abdollahi, 2013). As for chromosomal aberrations, we can see the appearance of micro-nuclei, chromosomal destruction or damage, alteration in the number of chromosomes, exchange of sister chromatids. In the case of changes in epigenetic mechanisms, there may be changes in the level of histomas, DNA methylation or errors in miRNA transcription (Mostafalou & Abdollahi, 2013).

Some of the effects associated with the presence of pesticides in the human body are neuro-degenerative diseases, chronic diseases and tumours (Hernández et al., 2013). The relationship between pesticides and neuro-degenerative disease has also been reported by other authors (Kanavouras et al., 2011; Tanner et al., 2011). A significant number of studies classify pesticides as endocrine disruptors (Myers et al., 2016). One of the main public health problems in the in the 21st century may turn out to be chronic diseases, often related to exposure to pollutants, namely pesticides (Mostafalou & Abdollahi, 2013). There is also evidence of immunotoxicity induced by pesticides, which may be related to immunosuppression, allergies and autoimmune diseases. Immunosuppression may, in turn, be related to the appearance of malignant tumours (Corsini et al., 2013).

Exposure to organophosphates is related to the loss of mental capacities, which can result in dementia (Zaganas et al., 2013; Medehouenou et al., 2014). Exposure to pesticides, including paraquat, is related to the onset of Parkinson's disease (Tanner et al., 2011; Moretto & Colosio, 2013). In this specific case, exposure to toxics can trigger the disease, or anticipate its onset (Moretto & Colosio, 2013). Imidazolinone herbicides are related to the growth of bladder tumours (Koutros et al., 2015). Pesticide exposure is related to the increase in cases of cancers in different organs (Dardiotis et al., 2013; Parrón et al., 2014). There are also indications that pesticide exposure may be related to asthma, through exposure through the respiratory tract (Kim et al., 2016). A study sought to relate the toxicological importance of each subgroup of pesticides, concluded that they are related to tumours of the nervous, digestive, hematopoietic and male reproductive systems. Other diseases associated with pesticides are: Alzheimer, Parkinson, amyotrophic lateral sclerosis, asthma, infertility and congenital diseases (Mostafalou & Abdollahi, 2017).

One of the most studied herbicide is glyphosate. Glyphosate is classified as probably carcinogenic to humans, group 2A. This classification is due to studies in humans and animals (IARC, 2015). The toxic effect of glyphosate differs depending the way it is present in different commercial products (Moon et al., 2017). The increase in glyphosate application worldwide and increasing exposure time, has been reflected, for example, in the increase of its concentration in human urine and in the growing number of evidences regarding its long-term toxicity which led to its classification as a carcinogen (Corsini et al., 2012; Myers et al., 2016; Nicolopoulou-Stamati et al., 2016; Van Bruggen et al., 2017; Tarazona et al., 2017; Gillezeau et al., 2019). Thus, it is urgent to invest more in independent studies.

Once released into the environment, glyphosate can become a waste or by-product called AMPA[1] (Hosseini Baie & Ogbourne, 2016). Glyphosate tends to be adsorbed by the soil, after which it is ingested by living beings (Van Stempvoort et al., 2016). It affects the microbiota both in soil and water, and in the body of other larger organisms (Van Bruggen et al., 2017). It has been found in all types of waters, underground, surface, rivers, ponds and lakes (Van Stempvoort et al., 2016; Sasal et al., 2017). Glyphosate is also found in soil, in microorganisms, non-target plants and animals (Hosseini Baie & Ogbourne, 2016).

[1] AMPA: α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid

Glyphosate is toxic and dangerous to aquatic environments, with significant effects at concentrations below 2.6 mg/L. It can be particularly harmful in ponds and irrigation channels since electrical conductivity can increase substantially. In these scenarios, toxicity can also increase, due to changes in physical-chemical factors (temperature, pH, O_2 concentration, presence of different inert, other chemicals or water hardness). It has causes serious impacts on algae and aquatic plants. It also presents effects of greater development and reproduction rates in gastropods with shells and worms (Jurado et al., 2011).

Several studies indicate that glyphosate is a carcinogen (Vazquez et al., 2017). Glyphosate impairs sperm mobility and causes DNA fragmentation in these reproductive cells. It negatively affects reproductive capacity (Anifandis et al., 2018; Myers et al., 2016; Avila-Vazquez et al., 2018). Exposure to glyphosate affects the gestational age of fertile women (Sanin et al., 2009). Glyphosate, as well as other pesticides present in urban environments, is related to congenital problems and spontaneous abortions (Sanin et al., 2009; Avila-Vazquez et al., 2018).

Finally, glyphosate is found in food composition, both human and animal (Niemann et al., 2015; Hosseini Baie & Ogbourne, 2016; FAO & WHO, 2020). As traces are also found in human urine, causing it to present serious risks to human health (Niemann et al., 2015).

Herbicides are a public health problem (WHO, 2019). In order to reduce risks, manuals of good practices in the handling, storage and preparation of solutions have been published, as well as recommended training for applicators (WHO, 2019). Another problem detected is the presence of pesticide residues in products for human consumption (ONU & FAO, 2020).

1.1.5. Urban definition and demography

There is a wide variety of definitions for the classification of urban areas, as they vary from country to country, organizations or institutions, adapting to needs or according to pre-established criteria. Portugal and the European Union are no exception (Dijkstra & Poelman, 2014).

In Portugal, there are different territorial units (TIPAU, 2014): administrative divisions (parish, municipality, intermunicipal communities, districts and autonomous regions);

territorial units for statistical purposes (PUA[2], MUA[3], and PRA[4]), and census territorial units (sections, subsections, place, urban place, statistical cities).

The European Union, through the organization responsible for statistics, Eurostat, sought to establish homogeneous criteria for member states for statistical studies of territorial units. At regional level, there are different levels of administrative and statistical divisions, NUTS I, II, and III. Cities are studied through the divisions LAU 1 and LAU 2 (Eurostat, 2017). According to Eurostat, the Portuguese population living in cities was 43.6% and in towns 30.2%, totalling 73.8% in the set of these two areas (Eurostat, 2017). In another case, the sum of the inhabitants of cities and metropolitan areas was 62.2% (DGT, 2016). According to INE, in 2013, 73.1% of the Portuguese population was living in predominantly urban areas. According to the 2011 census, the number of inhabitants living in places with a population of over 10,000 inhabitants in Portugal was 4,506,906 which corresponds to 42.7% (INE, 2011; RTP, 2013). As for the population distribution by gender and age, the main relevant indicators are shown in table 1.

Table 1. Gender distribution and age group distribution by type of areas of urbanization (Source: INE, 2019).

Distribution of the population by areas of urbanization (%)				
	Predominantly Rural Area	Median Urban Area	Predominantly Urban Area	National total
Men	47.9	47.9	47.0	47.2
Women	52.1	52.1	53.1	52.8
14 years old or less	9.7	12.0	14.5	13.5
15 to 64 years old	60.4	65.7	64.7	64.4
65 or older	29.9	22.2	20.8	22.1

[2] PUA - Predominantly urban areas
3 MUA - Medially urban areas
4 PRA - Predominantly rural areas

1.2. Perceptions and behaviours to the use of pesticides

Studying and understanding the population's perceptions about herbicides use is considerably important to the definition of public policies that should be followed in this domain, to satisfy different requirements and concerns (Ahmed et al., 2011). However, it appears that the number of scientific studies published on population perception about the effect of synthetic chemical herbicides use, is scarce. There are more face-to-face studies targeting farmers and/or operators than for the general population. It was also observed that there are fewer studies in Europe, when compared to other continents (Remoundou et al., 2014). Those studies, mainly focused on general pesticides, where herbicides are included, seek to understand if there are differences of perceptions between urban and rural populations, as well as between farmers and the general population, age, gender or education level (Flynn et al., 1994; Coppin et al., 2002; Ahmed et al., 2011; Remoundou et al., 2014).

Currently, public opinion has expressed an increasing concern about the safety of herbicides use, whether through associations, civic initiatives, or protests. This concern is reflected by the number of studies, and reports prepared and published on the harmful effects of these products on human and environmental health (Coppin et al., 2002; Corsini et al., 2012; IARC, 2015; Gillezeau et al., 2019).

In general, studies indicate that women tend to show more concern for health and environmental protection (Flynn et al., 1994; McCrigh et al., 2010; Ahmed et al., 2011; Hirsch & Baxter, 2011; Remoundou et al. 2014; Kunin & Lucero, 2020). Regarding pesticides, the conclusions are similar(Cabrera & Leckie, 2009; Hirsch & Baxter, 2011; Ahmed et al., 2011; Remoundou et al. 2014; Kunin & Lucero, 2020). Women also tend to be more concerned about the negative impact of pesticides on water quality (Ahmed et al., 2011), tending to see weed control and pesticide use less necessary (Cabrera & Leckie, 2009; Hirsch & Baxter, 2011). Women indicate less use of pesticides (Ahmed et al., 2011; Hirsch & Baxter, 2011). Regarding risk prevention care and measures related to herbicide exposure, women indicate to be more careful, protecting themselves, and taking more preventive measures (Cabrera & Leckie, 2009; Remoundou et al. 2014; Kunin & Lucero, 2020). Besides that, women are less trained to handle and use herbicides safely (Remoundou et al. 2014). On the other hand, men tend to care less for themselves and make more risky decisions, both in their actions and in taking preventive and protective measures (Remoundou et al. 2014; Kunin & Lucero, 2020).

Biological and social factors are among the reasons given by women for the greatest concern about the health and environmental impacts of chemicals (Flynn et al., 1994). They are exposed to the same risk as men but do not have the same access to the decision-making process of preventive or protective measures (Remoundou et al. 2014). Besides that, they are responsible for the protection and maintenance of family life and that of those around them, as well as the protection of the environment (Kunin & Lucero, 2020). Gender is relevant, with women consuming more literature related to the environment and presenting more environmental concerns. Consuming literature related to the environment is related to greater environmental concern and also environmental education (Mobley et al., 2010).

Age is also a relevant factor that affects the perception of the utility and benefits of herbicides, although few studies have taken this variable into account, especially those on the professional use of herbicides. However, some of the results obtained from these types of studies may seem contradictory. Older people tend to see herbicides as more useful and beneficial, while younger people report greater reserves in their use (Ahmed et al., 2011). As for the perceived health and environmental risks associated with herbicide use, there appear to be no differences (Coppin et al., 2002). For example, Huddart-Kennedy et al. (2009) indicated that age was only a statistically significant variable when analyzing some behaviors associated with environmental protection. In people's perception to climate change, age is clearly a significant variable, with younger people being more aware about this issue (Mcright, 2010).

Education is also reported to be relevant, with those with higher levels of education showing more concern about the hazards associated with herbicides (Coppin et al., 2002). In Sweden, education is also associated with use, with people in the 9th grade or below showing more frequent use of pesticides (Ahmed et al., 2011).

The difference between the rural world and the urban environment has also been the subject of some studies. Regarding the perception of benefits, people from the rural world tend to see pesticides use as safer and as more necessary than people from the urban world. Trust in businesses and in public institutions have also been studied, with public authorities standing out on the positive side, when compared pesticide brands. Residents of rural areas seem to have more confidence in companies than residents of urban areas (Coppin et al., 2002). Differences between urban and rural populations regarding environmental concerns have been decreasing (Huddart-Kennedy et al., 2009).

Most studies focus on farmers, the principal group of herbicide users, including in the domestic environment. Farmers have a positive view of pesticides, indicating that have a lower impact on environment, while the rest of the population has a more negative perception (Ahmed et al., 2011; Remoundou et al., 2014). Another study sought to determine the origin of knowledge about pesticides. Small farmers have fewer studies, and their knowledge is obtained through empirical ways, while technicians and large farmers acquire it through formal studies. However, there is no difference between these two types of farmers regarding the adoption of protective measures (Ríos-González et al., 2013).

Farmers of regions where lower rates of herbicide-resistant weeds exists, tend to be less skeptical about chemicals. Since herbicide resistance is related to geographical location, weed control practices and the perceptions of the risks vs. benefits of herbicides can be adapted to locations and needs. Faith or techno-optimism in herbicides, and the results that these historically provide, can be very harmful to the environment, since it can amplify the problem of resistance of unwanted plants and make the problem uncontrollable. This speech also delays the dissemination of integrated weed control plans. The industry also encourages and develops a pro-technology feeling among farmers. Further studies are needed on the extent of the ideology created and propagated by the private sphere (Dentzman et al., 2016).

Another study seeks to relate the perception about herbicides technology with biotechnology, concluding that the two themes are perceived as interrelated, and that the population has little knowledge about technological issues in general. It was also concluded that there are differences in the perception of benefits/risks associated with these two technologies (pesticides and biotechnology) (Peterson, 2000). Techno-optimism may be related to the perception and use of herbicides, as well as weed control practices and the development of herbicide-resistant weeds (Dentzman et al., 2016).

It is verified that places with herbicide-resistant weeds is where there is a greater legal limitation in the use of these compounds. Besides that, there is a demand for safer spraying practices, and need for population warning (Dentzman et al., 2016).

Cultural diversity can also contribute to different ways of addressing problems related to the use of pesticides. It appears that migrant workers tend to associate pesticides with health risks much less, which is probably due to differences in language and literacy, according to Remoundou et al. (2014).

Another relevant variable for this work is the subject of environmental education and differences between academic backgrounds. The areas of study influence perceptions of people regarding environmental problems (Yapici et al., 2017). Environmental education has a significant positive impact on the perception of different environmental issues related to pesticides, such as: industrial and transport air pollution, water and soil pollution, air transport pollution, loss of biodiversity, reduction of natural spaces, drought, and population growth (Carmi & Alkaher, 2019). The perception of different risks, such as ecological, chemical waste, resource depletion or global environmental risks, are more perceived by women and people with an interest in the subject of the environment, Healthcare workers tend to have a greater perception of ecological risks and are the ones who least devalue the threats associated with pesticides (Yapici et al., 2017).

Finally, the presence of spontaneous vegetation, roadside or pavements is well perceived, although vegetation in gardens is slightly better perceived (Weber et al., 2014).

2. Material and methods

2.1. Questionnaire survey

Citizens' perceptions on weeds and their control using synthetic chemical herbicides was assessed through an inquiry by questionnaire. To obtain more objective data it was considered to include more closed-ended questions in the survey. Many answers are grouped in a Lickert scale from which respondents choose one option that best aligns with their point of view (Kumar, 2011; Stockemer, 2019).

When formulating a questionnaire there are a number of considerations that must be considered and which this study has followed. The questions addressed in the questionnaires must be logically ordered, following similarity criteria. Generally, questions start from general to specific, impersonal to personal and easy to difficult, with questions belonging to the same topic suitably grouped. The number of questions must be as small as possible, and at the same time, as many as essential to obtain the number of necessary answers. More questions increase response time in turn increasing the likelihood that fewer respondents will answer the entire questionnaire (Stockemer, 2019). The questions must be constructed according to the objective of the survey and the variables identified (Kumar, 2011).

For this work, we chose to conduct an online survey, made available for one month (Figures 7 and 8). The survey was disseminated by email and social networks. Regarding social networks, three different networks were used: Facebook, Twitter and Instagram (Figure 7). Information was shared in different groups with environmental and pesticide use concerns and for residents of urban areas. Associations and other formal institutions were contacted by email and a formal document was prepared requesting cooperation and dissemination of the questionnaire. In the case of social networks, a small informal text (with the link to access the questionnaire) was created (figure 7).

Figure 7: Printscreen of a post in a social network, accompanied by a short informative text.

Figure 8: Printscreen of the survey header in the Google forms platform.

Online surveys have a major advantage in terms of cost per survey, as they are much less expensive than surveys conducted face-to-face. There is also a clear advantage in analyzing controversial or socially uncomfortable topics, as respondents are not confronted with an interviewer and may, in theory, be more comfortable to answer what they really think about a given subject. However, access to the Internet may still be conditional for parts of the population, and together with the complexity and specificity of the subject addressed, these factors may have discouraged the participation some people.

For the online survey the digital platform Google® forms was chosen (Figure 8). The main disadvantage found on this platform was the need for each user to have a Google® account to be able to access the questionnaire through the shared link. This requirement was created to limit one response per user. No personal information was collected, not even an email address. Each response was, therefore, anonymous. Respondents were not allowed to edit their responses after submission. In order to circumvent the problem of prior registration with Google® to access and answer the questionnaire through the link, there was the option to send it via e-mail.

2.2. Sample construction and questionnaire structure

The principle underlying the construction of the sample is to reduce the differences between the sample itself and the studied population, in order to obtain results closer to reality (Kumar, 2011). Taking into account the means used to prepare this work, the sample obtained is random (Stockemer, 2019).

The questionnaire entitled "Perceções da população sobre a utilização de herbicidas em zonas urbanas" (Table 2), consists of three distinct parts: presentation or header, questionnaire itself and footer. In the header, it was clarified to the respondents what were the objectives of the work and presented the team involved in the research.
The questionnaire is divided into five different sections addressing the following information (Table 2):

A - Area of residence, from question 1 to question 6.1;
Characterization of the area of residence and type of accommodation. Unwanted plants characteristics: perceptions of the presence of weeds, need for control.

B - Use of herbicides, from question 7 to question 11;
Importance of herbicides, frequency of use, knowledge, safety, perceptions of risks, self-assessment of their knowledge.

C - Control of weeds in the area of residence, from question 12 to question 18;
Knowledge of weed control by the municipality, techniques used and dissemination of the control actions.

D - Synthetic chemical herbicides in urban areas - health and environment, from question 19 to question 21;
Assessment of perceptions about the health and environmental risks and impacts of herbicides.

E - Know more about the respondent, from question 22 to 32.1.
Respondent's sociodemographic profile, gender, age, qualifications, occupation and profession.

The questionnaire consisted of 38 questions in total, 31 of them were mandatory, six optional, and one was dependent on the previous answer.

Table 2. Questionnaire structure.

Section 1 - Area of residence.

Question number	Question	Answer - options
1	Your place of residence is:	1. City / urban area 2. Surroundings of the city / semi-urban area 3. Rural area
2	Your home is:	1. Apartment 2. House
3	Does your house have a garden?	1. Yes 2. No
4	Is there a green space near your home?	1. Less than 500 m 2. Between 500m to 1km 3. No
5	In your area of residence there are weeds in:	
5a	Pedestrian walks and paths	1. Yes 2. No 3. I do not know 4. Not applicable
5b	Sidewalks and road separators	1. Yes 2. No 3. I do not know 4. Not applicable
5c	Parks and gardens	1. Yes 2. No 3. I do not know 4. Not applicable
5d	Roundabouts	1. Yes 2. No 3. I do not know 4. Not applicable
5e	Walls or rooftops	1. Yes 2. No 3. I do not know 4. Not applicable
5.1	In your area of residence, are there weeds elsewhere?	Open
6	Is it important for you to see the following structures / communication routes without weeds?	
6a	Pedestrian walks and paths	1. Yes 2. No 3. I do not know
6b	Sidewalks and road separators	1. Yes 2. No 3. I do not know
6c	Parks and gardens	1. Yes 2. No 3. I do not know
6d	Roundabouts	1. Yes 2. No 3. I do not know
6e	Walls and rooftops	1. Yes 2. No 3. I do not know
6.1	Is there any other place you think weed control is important?	Open

Table 2. Questionnaire structure (continuation).

Section 2 - Use of herbicides.

Question number	Question	Answers
7	Do you know any herbicide?	1. Yes 2. No 3. I do not know
8	Have you heard about glyphosate (ex: Roundup®)?	1. Yes 2. No 3. I do not know
9	Do you use herbicides?	1. Never 2. Rarely 3. Occasionally 4. Often 5. Daily
10	Where do you use herbicides?	
10a	Garden	1. Yes 2. No
10b	Vegetable garden	1. Yes 2. No
10c	Agriculture	1. Yes 2. No
10d	Paved areas (e.g. garage entrance or sidewalks)	1. Yes 2. No
10.1	If you use herbicides elsewhere, please indicate where	Open
11	What type of herbicides (origin) do you usually use?	1. Chemical origin 2. Biological origin 3. Both origins 4. I don't know 5. I don't care about the origin 6. I don't use herbicides

Table 2. Questionnaire structure (continuation).

Section 3 - Control of weeds in the area of residence.

Question number	Question	Answers
12	Do you know if the municipality controls weeds?	1. Yes 2. No 3. I do not know
13	Are you usually informed about control actions?	1. Yes 2. No
14	If you answered “no”, would you like to be informed?	1. Yes 2. No
15	How are you usually informed about control actions?	
15a	Street warning / posting of notifications in public places	1. Yes 2. No
15b	By email or letter by mail	1. Yes 2. No
15c	Local media (e.g., newspaper)	1. Yes 2. No
15d	Internet (eg.local authority page)	1. Yes 2. No
15e	SMS	1. Yes 2. No
15.1	If you are informed about weed control actions through other means, please, indicate it.	Open
16	Do you know what methods are used to control weeds?	1. Synthetic chemical herbicides 2. Biological origin herbicides 3. Both type (chemical and biological) herbicides 4. Mechanical methods (e.g. cutting or others) 5. Integrated methods (using various methods to control weeds) 6. I do not know 7. Other

Table 2. Questionnaire structure (continuation).

Section 3 - Control of weeds in the area of residence (continuation).

Question number	Question	Answers
17	If synthetic chemicals are used, do you know what active substances are used in them?	1. Yes 2. No 3. Chemical / biological products are not used
18	Of the following expressions, check the option that best fits you	
18a	It is important to use herbicides to control weeds in urban areas	1. Not important 2. Not very important 3. Moderately important 4. Important 5. Very important
18b	It is important to reduce the use of herbicides of synthetic chemical origin in urban areas	1. Not important 2. Not very important 3. Moderately important 4. Important 5. Very important
18c	It is important to ban herbicides of synthetic chemical origin in urban areas	1. Not important 2. Not very important 3. Moderately important 4. Important 5. Very important
18d	It is important to ban glyphosate use in urban areas	1. Not important 2. Not very important 3. Moderately important 4. Important 5. Very important
18e	It is important to use alternatives (e.g. mechanical, manual and biological means) to synthetic chemicals herbicides	1. Not important 2. Not very important 3. Moderately important 4. Important 5. Very important
18f	The increase in costs related to alternative means is an obstacle to their use	1. Not important 2. Not very important 3. Moderately important 4. Important 5. Very important

Table 2. Questionnaire structure (continuation).

Section 4 - Synthetic chemical herbicides in urban areas.

Question number	Question	Answers
19	Do you think herbicides are safe?	1. Yes 2. No 3. I do not know
20	Do you consider yourself informed about the risks associated with herbicides?	1. Yes 2. No 3. I do not know
21	In your opinion, the use of herbicides is harmful to:	
21a	Human health	1. Yes 2. No 3. I do not know
21b	Animal health	1. Yes 2. No 3. I do not know
21c	Loss of biodiversity	1. Yes 2. No 3. I do not know
21d	Destruction of natural areas	1. Yes 2. No 3. I do not know
21e	Air pollution	1. Yes 2. No 3. I do not know
21f	Soil contamination	1. Yes 2. No 3. I do not know
21g	Contamination of water courses	1. Yes 2. No 3. I do not know
21.1	Do you know any other situations in which the application of herbicide is harmful?	Open

Table 2. Questionnaire structure (continuation).

Section 5 - Know a little more about yourself.

Question number	Question	Answers
22	Indicate the municipality of residence	Open
23	Indicate the parish of residence	Open
24	Year of birth	Open
25	Gender	1. Female 2. Male 3. Other
26	Education (complete)	1. Up to 4th year (old primary school) 2. 4th Year (2nd cycle) 3. 6th year (2nd cycle) 4. 9th year (3rd cycle) 5. 12th year (secondary) or equivalent 6. Graduation 7. Master's 8. PhD
27	Did you have academic training on environment areas / ecology?	1. Yes 2. No
28	Professional situation	1. Employed 2. Unemployed 3. Retired 4. Student 5. Household 6. Other (open)
29	What is (or was) your profession?	Open
30	From the following expressions, check the option that best describes you:	
30a	I am a member of an ENGO (environmental non-governmental organization)	1. Yes 2. No
30b	Environmental protection is important to me	1. Yes 2. No
30c	Biodiversity protection important to me	1. Yes 2. No
30d	Am I interested in the topic addressed in this questionnaire	1. Yes 2. No
31	My knowledge about herbicides is:	1. Very vague or null 2. Vague 3. Reasonable 4. Good 5. Very good
32	Are you aware of any activity, association or project related with weed control?	1. Yes 2. No
32.1	If so, which one?	Open

2.3. Pre-test and application of the questionnaire

Pre-testing a questionnaire is critical to understand each question, examine consistency, and evaluate the work as a whole. It also aims to identify potential errors and difficulties in understanding and interpreting the questions. The people interviewed in the pre-test should be as representative as possible of the population being surveyed and not be involved in the elaboration of the questionnaire (Kumar, 2011; Stockemer, 2019).

The pre-test was carried out with 15 people with different ages, education level (academic and non-academic education) and gender. Respondents in the pre-test were asked to answer the questionnaire, expose doubts, and indicate questions that were difficult to understand, confusing or ambiguous. With their feedback and suggestions the questionnaire was improved in order to make it clearer and easier to answer**.**

2.4. Statistical analysis and data processing

Statistical analysis was performed using SPSS®. A descriptive analysis was carried out and several groups were established to compare their responses, such as area of residence, accommodation type, existence of a private garden and proximity to a public green space.

Respondents were also grouped according their age (17-24, 25-34, 35-44, 45-54, 55-64, 65-81), gender (male, female, other), education (Up to the 9th year, 12th year, College education), with or without academic background in environmental/ecology areas (ABE), and professional situation (Employed, Unemployed, Retired, Student, Household). Chi-squared (χ^2) analysis were performed to evaluate if belonging to different groups influenced their answers. Three significance levels were considered ($p < 0.05$, $p < 0.01$, $p < 0.001$, respectively, significance lower than 5%, 1% and 0.1%). This test is important to:

- Ascertain whether or not two groups are independent in the population.
- Compare the values observed in the sample with the expected values (those that would be obtained in case of independence of the variables).

In this work we used the Kruskal-Wallis, a non-parametric test, for comparing if independent samples were equal or different sample sizes in question number 18 (the option that best fitted the respondents)

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3. Results

3.1. Characterization of the sample

The reception of responses, through the Google® Forms platform, lasted one month, and 491 validated questionnaires were obtained.

Although it is not a fully representative study of the mainland Portuguese population, the proportion of female and male respondents collected in this survey (53.28% and 46.72%, respectively; Table 3) is very similar to that of the Portuguese population (52.8% and 47.2%, respectively, INE, 2011) and can be used as a proxy to this demographic indicator. Although this survey was answered online, which typically constrains the respondents to those with the knowledge and access to this type of tools (Lee et al., 2014), these results are somehow encouraging regarding this representativeness.

This study did not seek to present to respondents what should be understood by a city, an urban area or a rural area. Instead, it opted to analyze how people perceive the area where they live, in order to better understand their framework of the buildings around them. More than a definition, the respondents' perception of whether they live in an urban or rural area, was for this work, more important as it relates more closely to their opinions and perceptions. According to INE (2019) 72.25% of the Portuguese population lives predominantly in urban parishes. It can be observed that our sample is composed of 51.5% of respondents living in urban areas, 22.0% in semi-urban areas and 26.48% in rural areas (Table 3). One of the reasons that may explain these differences is the perceived notion of what are the “technical” differences between these areas. In this sense, a resident of a predominantly urban area living in the vicinity of a city could easily indicate living in a semi-urban area. What this selection indicates is whether respondents feel or perceive that they live surrounded by many houses or buildings, or in less densely occupied areas. Their perception of 'urbanity' is also interesting to understand in this study.

Analyzing the sample, it can be seen that the age of the youngest respondent is 17 years old and of the oldest respondent has 81 years, resulting in a range of 64 years (Table 3). The average age is 42.7 years old. We obtained surveys from the 18 districts of mainland Portugal, as well as from the two autonomous regions of Azores and Madeira.

Residents in more urbanized areas were more likely to live in apartments, without a garden and closer to public green areas in contrast to residents of rural areas, who live in houses, own a garden and are further away from green spaces (Table 4). The degree of urbanization was also related to education and background in environmental areas/ecology. Respondents with higher education levels were mostly found in urban areas, followed by semi-urban and rural areas, respectively (Table 4).

Table 3: Sample description.

Sample			
Variable	Categories	N	%
Number of inquiries		491	
Place of residence	Urban area	253	51.53
	Semi-urban area	108	22.00
	Rural area	130	26.48
Accommodation type	Apartment	243	49.49
	House	248	50.51
Own a garden	Yes	273	55.60
	No	218	44.40
Proximity to a public green space	< 500m	301	61.30
	500m - 1km	116	23.63
	No garden nearby	74	15.07
Gender	Female	260	52.95
	Male	228	46.44
	Other	3	0.61
Education	Up to the 9th year	16	3.26
	12th year	91	18.53
	Graduation	202	41.14
	Master's	120	24.44
	Ph.D.	62	12.63
Age	17-24	35	7.13
	25-34	114	23.22
	35-44	137	27.90
	45-54	122	24.85
	55-64	58	11.81
	65-81	25	5.09
Employment status	Employed	352	71.69
	Unemployed	52	10.59
	Retired	28	5.70
	Student	50	10.18
	Household	9	1.83
Academic background in environmental areas/ecology	Yes	201	40.94
	No	290	59.06
Herbicide users	Yes	115	23.42
	No	376	76.58

Table 4: Description of the type of accommodation, owning a garden, proximity to a public green space, age, gender, education, background training in environmental areas/ecology and employment status by area of residence. [1] Statistic analysis was not taken into account due to insufficient number of responses.

Independent variables		Rural Area N	Rural Area %	Semi-urban Area N	Semi-urban Area %	Urban Area N	Urban Area %
Place of residence		130	26.5	108	22.0	253	51.5
Accommodation type	House	124	95.4	73	67.6	51	20.2
	Apartment	6	4.6	35	32.4	202	79.8
	p-value	$\chi2 = 3.953$; $p < 0.001$					
Own a garden	Yes	118	90.8	80	74.1	75	29.6
	No	12	9.2	28	25.9	178	70.4
	p-value	$\chi2 = 149.111$; $p < 0.001$					
Proximity to a public green space	< 500m	59	45.4	56	51.9	186	73.5
	500m - 1km	29	22.3	32	29.6	55	21.7
	No garden nearby	42	32.3	20	18.5	12	4.7
	p-value	$\chi2 = 59.614$; $p < 0.001$					
Gender	Female	75	57.7	59	54.6	126	49.8
	Male	54	41.5	49	45.4	125	49.4
	Other1	1	0.8	0	0.0	2	0.8
	p-value	$\chi2 = 2.260$; $p = 0.323$					
Education	Up to the 9th year	5	3.8	5	4.6	6	2.4
	12th year	32	24.6	21	19.4	38	15.0
	College education	93	71.5	82	75.9	209	82.6
	p-value	$\chi2 = 7.138$; p = 0.129					
Age	17-24	19	14.6	5	4.6	11	4.3
	25-34	26	20.0	27	25.0	61	24.1
	35-44	31	23.8	38	35.2	68	26.9
	45-54	32	24.6	23	21.3	67	26.5
	55-64	18	13.8	11	10.2	29	11.5
	65-81	4	3.1	4	3.7	17	6.7
	p-value	$\chi2 = 21.950$; $p < 0.05$					
Employment status	Employed	87	66.9	82	75.9	183	72.3
	Unemployed	16	12.3	9	8.3	27	10.7
	Retired	4	3.1	6	5.6	18	7.1
	Student	19	14.6	7	6.5	24	9.5
	Domestic	4	3.1	4	3.7	1	0.4
	p-value	$\chi2 = 14.135$; $p = 0.078$					
Academic background in environmental areas/ecology	Yes	40	30.8	45	41.7	116	45.8
	No	90	69.2	63	58.3	137	54.2
	p-value	$\chi2 = 8.108$; $p = 0.018$					

3.2. People's perceptions regarding weeds in their areas of residence

The questionnaire focused on understanding people's perceptions of the presence of weeds around their homes, particularly on pedestrian walks and paths, sidewalks and road separators, parks and gardens, roundabouts, and walls or rooftops.

Globally, results indicate that there were high levels of perceptions on the presence of weeds in all locations, with more than 60% claiming to see them in listed locations (Fig. 9).

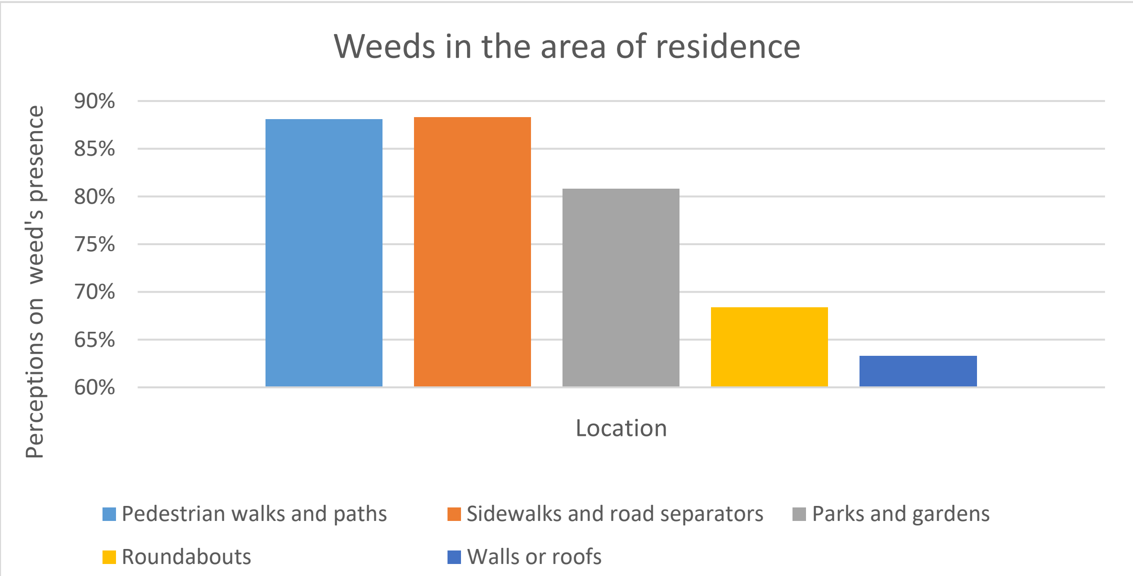

Figure 9: Perceptions of the presence of weeds in the residence area in five different locations.

It was found that the most significant differences in the perceptions on the presence of weeds were due to the accommodation type and existence of a garden in the dwelling, with these respondents answering that there are more weeds in pedestrian walks and paths, sidewalks and road separators, roundabouts, and walls or rooftops, than the other respondents (Table 5).

Table 5: Presence of weeds perceived by area of residence, type of accommodation, owning a garden, proximity to a public green space, age, gender, education, background training in environmental areas/ecology and employment status by five proposed locations. [1]Statistic analysis was not taken into account due to insufficient number of responses.

		Perceptions of weed presence (%)									
Independent variables		Pedestrian walks and paths		Sidewalks and road separators		Parks and gardens		Roundabouts		Walls or rooftops	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Area of residence	Urban area	84.5	15.5	85.1	14.9	81.0	19.0	65.9	34.1	56.0	44.0
	Semi-urban area	91.7	8.3	88.7	11.3	77.5	22.5	69.1	30.9	67.6	32.4
	Rural area	92.2	7.8	93.8	6.2	83.7	16.3	72.7	27.3	72.9	27.1
	p-value	$\chi2= 5.847$		$\chi2= 5.288$		$\chi2= 1.117$		$\chi2= 1.291$		$\chi2= 8.307$	
		$p= 0.054$		$p = 0.074$		$p = 0.572$		$p = 0.524$		$p < 0.05$	
Accommodation type	House	93.7	6.3	93.6	6.4	80.6	19.4	74.2	25.8	70.4	29.6
	Apartment	82.3	17.7	82.5	17.5	81.0	19.0	62.4	37.6	54.4	45.6
	p-value	$\chi2= 13.588$		$\chi2= 12.296$		$\chi2= 0.010$		$\chi2= 5.605$		$\chi2= 91.92$	
		$p < 0.001$		$p < 0.001$		$p = 0.921$		$p < 0.05$		$p < 0.01$	
Own a garden	Yes	92.7	7.3	92.1	7.1	81.1	18.9	72.2	27.8	70.2	28.9
	No	82.3	17.7	83.1	16.9	80.5	19.5	63.6	36.4	53.3	46.7
	p-value	$\chi2= 11.129$		$\chi2= 7.786$		$\chi2= 0.028$		$\chi2= 2.889$		$\chi2= 9.976$	
		$p < 0.01$		$p < 0.01$		$p = 0.867$		$p = 0.089$		$p < 0.01$	
Proximity to a public green space	< 500m	88.4	11.6	87.2	12.8	82.2	17.8	69.3	30.7	60.5	39.5
	500m - 1km	84.0	16.0	88.2	11.8	80.4	19.6	67.5	32.5	60.8	39.2
	No garden nearby	93.7	6.3	93.4	6.6	71.4	28.6	65.0	35.0	77.8	22.2
	p-value	$\chi2= 3.480$		$\chi2= 1.866$		$\chi2= 2.338$		$\chi2= 0.338$		$\chi2= 0.579$	
		$p = 0.176$		$p = 0.393$		$p = 0.311$		$p = 0.845$		$p = 0.055$	
Age	17-24	87.5	12.5	80.0	20.0	66.7	33.3	50.0	50.0	76.2	23.8
	25-34	88.7	11.3	89.7	10.3	83.9	16.1	59.7	40.3	58.6	41.4
	35-44	91.2	8.8	88.8	11.2	82.9	17.1	72.1	27.9	69.6	30.4
	45-54	87.8	12.2	90.4	9.6	83.0	17.0	73.1	26.9	55.3	44.7
	55-64	83.3	16.7	87.0	13.0	73.9	26.1	67.4	32.6	60.5	39.5
	65-81	82.6	17.4	81.0	19.0	76.2	23.8	76.5	23.5	76.5	23.5
	p-value	$\chi2= 3.029$		$\chi2= 3.171$		$\chi2= 5.568$		$\chi2= 7.170$		$\chi2= 7.687$	
		$p = 0.696$		$p = 0.674$		$p = 0.351$		$p = 0.208$		$p = 0.174$	
Gender	Female	85.2	14.8	87.3	12.7	80.8	19.2	67.6	32.4	64.1	35.9
	Male	91.3	8.7	89.3	10.7	80.7	19.3	68.9	31.1	62.6	37.4
	Other1										
	p-value	$\chi2= 3.846$		$\chi2= 0.379$		$\chi2= 0.000$		$\chi2= 0.064$		$\chi2= 0.082$	
		$p = 0.050$		$p = 0.538$		$p = 0.988$		$p = 0.801$		$p = 0.775$	

Table 5: continuation.

Independent variables		Perceptions of weed presence (%)									
		Pedestrian walks and paths		Sidewalks and road separators		Parks and gardens		Roundabouts		Walls or rooftops	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Education	Up to the 9th year	86.7	13.3	78.6	21.4	73.3	26.7	58.3	41.7	84.6	15.4
	12th year	92.4	7.6	91.7	8.3	78.7	21.3	71.2	28.8	60.3	39.7
	College education	87.2	12.8	88.0	12.0	81.6	18.4	68.2	31.8	62.9	37.1
	p-value	$\chi2= 1.689$		$\chi2= 2.101$		$\chi2= 0.847$		$\chi2= 0.778$		$\chi2= 2.777$	
		p = 0.430		*p* = 0.350		*p* = 0.655		*p* = 0.678		*p* = 0.249	
Academic background in environmental area / ecology	Yes	86.5	13.5	89.1	10.9	81.9	18.1	67.3	32.7	62.4	37.6
	No	89.3	10.7	87.8	12.2	80.0	20.0	69.3	30.7	0.0	0.0
	p-value	$\chi2= 0.825$		$\chi2= 0.156$		$\chi2= 0.215$		$\chi2= 0.153$		$\chi2= 0.101$	
		p = 0.364		*p* = 0.693		*p* = 0.643		*p* = 0.695		*p* = 0.751	
Employment status	Employed	88.5	11.5	89.2	10.8	79.8	20.2	68.1	31.9	61.2	38.8
	Unemployed	80.0	20.0	81.0	19.0	89.5	10.5	65.7	34.3	62.5	37.5
	Retired	92.3	7.7	87.5	12.5	78.3	21.7	80.0	20.0	75.0	25.0
	Student	91.9	8.1	90.3	9.7	80.0	20.0	56.0	44.0	71.0	29.0
	Household	88.9	11.1	88.9	11.1	87.5	12.5	100.0	0.0	80.0	20.0
	p-value	$\chi2= 3.818$		$\chi2= 2.592$		$\chi^2= 2.373$		$\chi2= 6.848$		$\chi2= 3.047$	
		p = 0.431		*p* = 0.628		*p* = 0.667		*p* = 0.144		*p* = 0.550	

Overall, the importance given to no observe weed in the different proposed locations has results ranging from 47.9% (for roundabouts) to 64% (pedestrian walks and paths and walls and rooftops) (Fig. 10).

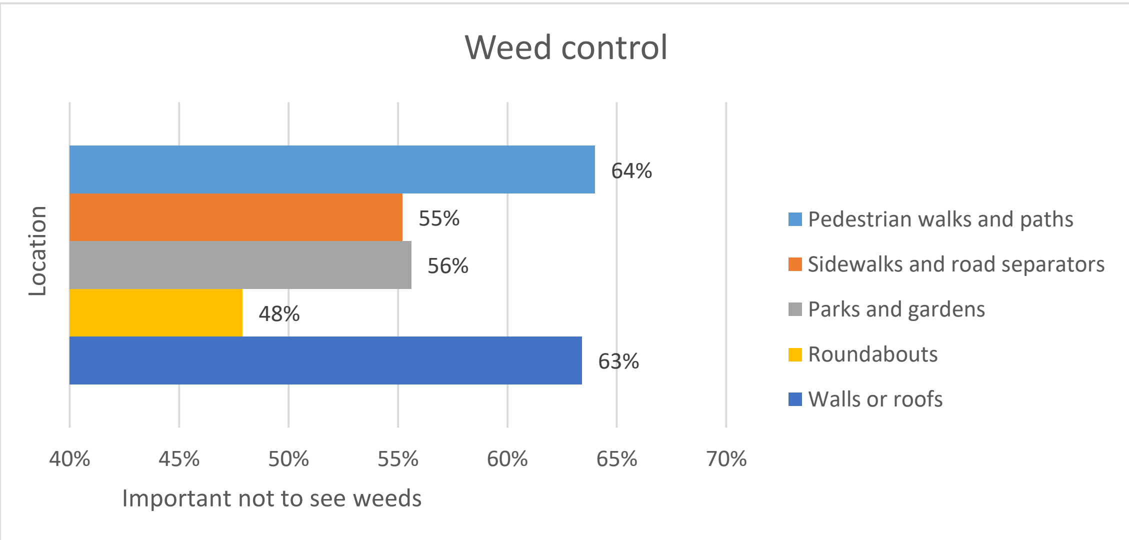

Figure 10: Importance given to no observe weeds in the listed locations.

People with academic background in environmental area/ecology, seem to have less interest in removing these plants at the described locations, and this influence on pedestrian walks and paths, and sidewalks and road separators is more evident. It is also observed that under 25 years old of age and students have a higher value in saying that is important not to see weeds in the place of residence (Table 6).

Table 6: Importance given nor to see weeds by area of residence, type of accommodation, owning a garden, proximity to a public green space, age, gender, education, background training in environmental areas/ecology and employment status. [1]Statistic analysis was not taken into account due to insufficient number of responses.

		Importance given to weed control (%)									
Independent variables		Pedestrian walks and paths		Sidewalks and road separators		Parks and gardens		Roundabout s		Walls or roofs	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Area of residence	Urban area	65.7	34.3	53.1	46.9	56.0	44.0	46.1	53.9	63.0	37.0
	Semi-urban area	63.6	36.4	56.7	43.3	54.5	45.5	47.5	52.5	62.6	37.4
	Rural area	61.1	38.9	58.1	41.9	55.6	44.4	51.6	48.4	64.8	35.2
	p-value	χ2= 0.786		χ2= 0.949		χ2= 0.067		χ2= 1.008		χ2= 0.140	
		p = 0.675		*p* = 0.622		*p* = 0.967		*p* = 0.604		*p* = 0.932	
Accommodation type	House	64.6	35.4	54.7	45.3	54.3	45.7	46.1	53.9	62.8	37.2
	Apartment	63.5	36.5	55.7	44.3	56.8	43.2	49.6	50.4	63.9	36.1
	p-value	χ2= 0.063		χ2= 0.047		χ2= 0.312		χ2= 0.556		χ2= 0.057	
		p = 0.802		*p* = 0.828		*p* = 0.577		*p* = 0.456		*p* = 0.811	
Own a garden	Yes	63.4	36.6	55.0	45.0	56.0	44.0	49.6	50.4	64.3	35.7
	No	64.8	35.2	55.5	44.5	55.0	45.0	45.7	54.3	62.3	37.7
	P-value	χ2= 0.104		χ2= 0.010		χ2= 0.043		χ2= 0.716		χ2= 0.200	
		p = 0.747		*p* = 0.922		*p* = 0.835		*p* = 0.397		*p* = 0.654	
Proximity to a public green space	< 500m	62.7	37.3	53.7	46.3	52.1	47.9	44.9	55.1	62.5	37.5
	500m - 1km	68.7	31.3	54.9	45.1	61.7	38.3	49.1	50.9	63.6	36.4
	No garden nearby	62.0	38.0	62.0	38.0	59.7	40.3	58.2	41.8	66.7	33.3
	p-value	χ2= 1.440		χ2= 1.597		χ2= 3.632		χ2= 3.921		χ2= 0.416	
		p = 0.487		*p* = 0.450		*p* = 0.163		*p* = 0.141		*p* = 0.812	
Age	17-24	93.8	6.3	72.4	27.6	78.1	21.9	63.3	36.7	73.3	26.7
	25-34	62.8	37.2	50.9	49.1	50.9	49.1	44.5	55.5	55.5	44.5
	35-44	63.9	36.1	53.4	46.6	51.5	48.5	42.5	57.5	65.9	34.1
	45-54	58.7	41.3	55.0	45.0	53.0	47.0	49.6	50.4	62.8	37.2
	55-64	56.1	43.9	52.6	47.4	58.2	41.8	46.4	53.6	56.6	43.4
	65-81	76.0	24.0	70.8	29.2	75.0	25.0	66.7	33.3	91.7	8.3
	p-value	χ2= 16.945		χ2= 6.985		χ2= 12.560		χ2= 8.403		χ2= 13.931	
		p < 0.01		*p* = 0.222		*p* < 0.05		*p* = 0.135		*p* < 0.05	

Table 6: continuation.

Importance given to weed control (%)											
Independent variables		Pedestrian walks and paths		Sidewalks and road separators		Parks and gardens		Roundabouts		Walls or rooftops	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Gender	Female	66.1	33.9	57.7	42.3	55.9	44.1	48.1	51.9	65.3	34.7
	Male	62.1	37.9	52.7	47.3	55.5	44.5	47.7	52.3	61.7	38.3
	Other1										
	p-value	χ2= 0.866		χ2= 1.148		χ2= 0.006		χ2= 0.008		χ2= 0.628	
		p = 0.352		p = 0.284		p = 0.937		p = 0.928		p = 0.428	
Education	Up to the 9th year	73.3	26.7	57.1	42.9	71.4	28.6	71.4	28.6	73.3	26.7
	12th year	69.7	30.3	58.1	41.9	63.2	36.8	51.2	48.8	63.0	37.0
	College education	62.3	37.7	54.4	45.6	53.1	46.9	46.2	53.8	63.1	36.9
	p-value	χ2= 2.261		χ2= 0.407		χ2= 4.369		χ2= 3.909		χ2= 0.663	
		p = 0.323		p = 0.816		p = 0.113		p = 0.142		p = 0.718	
Academic background in environmental area / ecology	Yes	59.1	40.9	49.0	51.0	50.5	49.5	40.0	60.0	59.5	40.5
	No	67.5	32.5	59.6	40.4	59.1	40.9	53.3	46.7	66.2	33.8
	p-value	χ2= 3.569		χ2= 5.182		χ2= 3.409		χ2= 7.930		χ2= 2.138	
		p = 0.059		p < 0.05		p = 0.065		p < 0.01		p = 0.144	
Employment status	Employed	61.8	38.2	55.7	44.3	54.0	46.0	47.0	53.0	62.0	38.0
	Unemployed	62.7	37.3	46.2	53.8	50.0	50.0	40.4	59.6	56.9	43.1
	Retired	75.0	25.0	66.7	33.3	70.4	29.6	66.7	33.3	84.6	15.4
	Student	80.0	20.0	59.5	40.5	70.5	29.5	57.1	42.9	71.1	28.9
	Household	44.4	55.6	33.3	66.7	25.0	75.0	22.2	77.8	50.0	2.4
	p-value	χ2= 8.746		χ2= 5.251		χ2= 10.358		χ2= 8.907		χ2= 8.042	
		p = 0.068		p = 0.262		p < 0.05		p = 0.063		p = 0.090	

3.3. Use of herbicides

About 88% of the respondent state to know at least one herbicide and 88.70% say they know what glyphosate is (Fig. 11). In general, the only determinant variables for knowing at least one herbicide is having a garden and academic background in environmental area/ecology (ABE) (Table 7). As knowing the active substance glyphosate, most variables (proximity to a public green space, age, gender, education, academic background in environmental area / ecology, and employments status) are significant, with emphasis to the variable age. Thus, students and those under 25 have higher values of ignorance about glyphosate than other age groups or employment status groups. It is noted that ABE is relevant to the knowledge of at least one herbicide and glyphosate, as it has a high ratio value for both issues (Table 7).

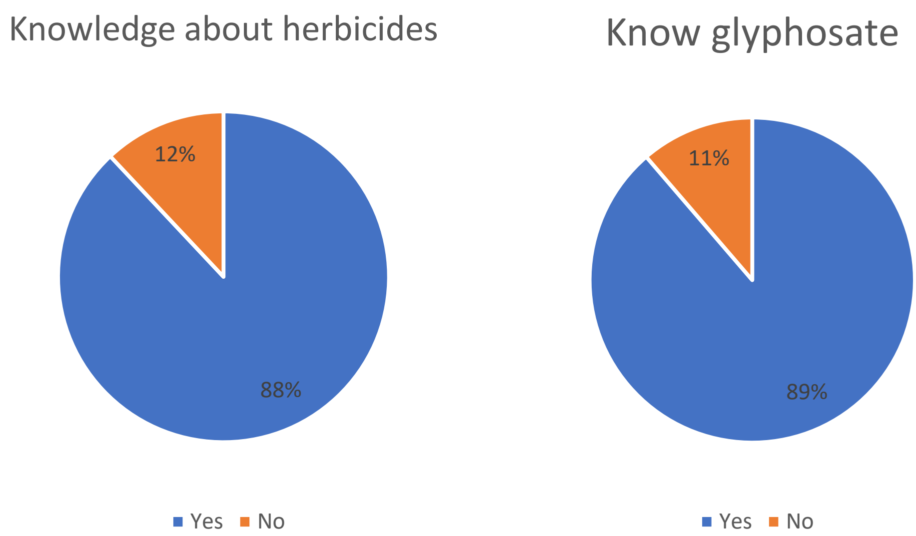

Figure 11: Overall results on knowledge about at least one herbicide, and glyphosate.

Table 7: Knowledge about herbicides by owning a garden, proximity to a public green space, age, gender, level of education, background training in environmental areas/ecology and employment. [1]Statistic analysis was not taken into account due to insufficient number of responses.

		Knowledge about herbicides							
Independent variables		Know an herbicide				Know what glyphosate is			
		Yes		No		Yes		No	
		N	%	N	%	N	%	N	%
Area of residence	Urban area	219	88.3	29	11.7	229	90.9	23	9.1
	Semi-urban area	90	84.9	16	15.1	90	84.9	16	15.1
	Rural area	116	89.9	13	10.1	114	87.7	16	12.3
	p-value	$\chi2 = 1.434$; $p = 0.488$				$\chi2 = 2.848$; $p = 0.241$			
Accommodation type	Apartment	205	86.1	33	13.9	215	89.2	26	10.8
	House	220	89.8	25	10.2	218	88.3	29	11.7
	p-value	$\chi2 = 1.532$; $p = 0.216$				$\chi2 = 0.111$; $p = 0.739$			
Own a garden	Yes	242	90.6	25	9.4	241	88.9	30	11.1
	No	183	84.7	33	15.3	192	88.5	25	11.5
	p-value	$\chi2 = 3.953$; $p < 0.05$				$\chi2 = 2.848$; $p = 0.241$			
Proximity to a public green space	< 500m	268	90.2	28	9.4	276	92.6	22	7.4
	500m - 1km	94	83.2	19	16.8	94	81.0	22	19.0
	No garden nearby	62	84.9	11	15.1	63	85.1	11	14.9
	p-value	$\chi2 = 4.989$; $p = 0.083$				$\chi2 = 12.329$; $p < 0.01$			
Age	17 - 24	28	87.5	4	12.5	21	61.8	13	38.2
	25-34	100	87.7	14	12.3	96	84.2	18	15.8
	35-44	119	88.1	16	11.9	127	93.4	9	6.6
	45-54	106	88.3	14	11.7	112	91.8	10	8.2
	55-64	48	84.2	9	15.8	54	94.7	3	5.3
	65 - 81	24	96.0	1	4.0	23	92.0	2	8.0
	p-value	$\chi2 = 2.320$; $p = 0.803$				$\chi2 = 33.4703$; $p < 0.001$			
Gender	Female	221	87.0	33	13.0	222	85.7	37	14.3
	Male	202	89.4	24	10.6	209	92.5	17	7.5
	Other1	2	66.7	1	33.3	2	66.7	1	33.3
	p-value	$\chi2 = 0.643$; $p = 0.423$				$\chi2 = 5.580$; $p < 0.05$			
Education	Up to 9th year	13	86.7	2	13.3	11	73.3	4	26.7
	12th year	73	83.9	14	16.1	72	80.0	18	20.0
	College education	339	89.0	42	11.0	350	91.4	33	8.6
	p-value	$\chi2= 1.748$; $p = 0.417$				$\chi2 = 13.112$; $p < 0.01$			
Academic background2	Yes	190	96.0	8	4.0	193	96.0	8	4.0
	No	235	82.5	50	17.5	240	83.6	47	16.4
	p-value	$\chi2 = 20.162$; $p < 0.001$				$\chi2 = 18.165$; $p < 0.001$			
Employment status	Employed	303	87.1	45	12.9	319	91.14	31	8.9
	Unemployed	48	92.3	4	7.7	44	84.62	8	15.4
	Retired	26	96.3	1	3.7	26	92.86	2	7.1
	Student	41	82.0	6	12.0	36	73.47	13	26.5
	Household	7	77.8	2	22.2	8	88.89	1	11.1
	p-value	$\chi2 = 3.864$; $p = 0.423$				$\chi2 = 14.806$; $p < 0.01$			

In general, the frequency in using herbicides is low, with 92.3% of them responding never or rarely using (Fig. 12). There are significant differences for the variables related to type of accommodation, with residents of urban areas having lower values of use than others, residents of houses and garden holders having higher values of use (Table 8).

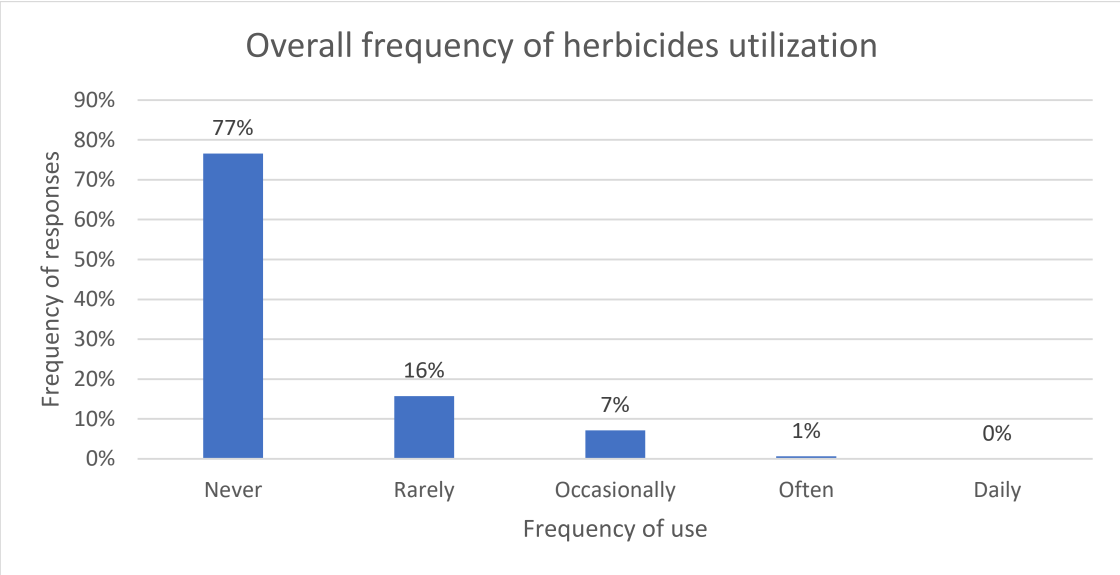

Figure 12: Overall frequency of herbicide utilization.

It is found that the use of herbicides in each of the proposed locations (garden, vegetable garden, agriculture, and paved areas) is low (Fig. 13). The first finding is that no independent variable significantly changes its use in agriculture. There is also a significant difference in young people under 25 years old, with much higher numbers for garden and vegetable garden. For the remaining variables, the key factors for greater use are the area of residence, accommodation type, and own a garden (Table 8).

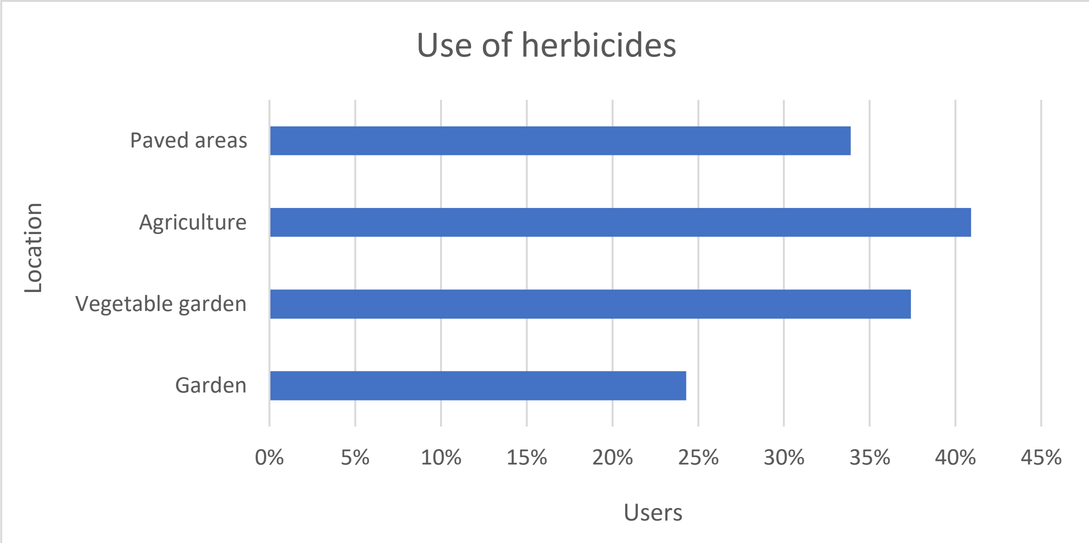

Figure 13: Overall use of herbicides by location.

Table 8: Frequency and location of use by residence, accommodation type, own a garden, proximity to public green space, age, gender, education, employment status. [1] Statistic analysis was not taken into account due to insufficient number of responses.

		Location of herbicide use (%)							
Independent variables		Garden		Vegetable garden		Agriculture		Hard surfaces	
		Yes	No	Yes	No	Yes	No	Yes	No
Area of residence	Urban area	5.5	94.5	7.9	92.1	9.1	90.9	4.3	95.7
	Semi-urban area	7.4	92.6	6.5	93.5	10.2	89.8	14.8	85.2
	Rural area	10.8	89.2	16.2	83.8	16.2	83.8	13.1	86.9
	p-value	$\chi^2 = 3.466$		$\chi^2 = 8.328$		$\chi^2 = 4.451$		$\chi^2 = 13.835$	
		$p = 0.177$		$p < 0.05$		$p = 0.108$		$p < 0.05$	
Accommodation type	Apartment	4.5	95.5	7.8	92.2	9.1	90.9	4.5	95.5
	House	10.1	89.9	11.7	88.3	13.3	86.7	13.3	86.7
	p-value	$\chi^2 = 5.572$		$\chi^2 = 2.089$		$\chi^2 = 2.232$		$\chi^2 = 11.597$	
		$p < 0.05$		$p = 0.148$		$p = 0.135$		$p < 0.01$	
Own a garden	Yes	10.6	89.4	13.2	86.8	12.8	87.2	12.1	87.9
	No	3.2	96.8	5.5	94.5	9.2	90.8	5.0	95.0
	p-value	$\chi^2 = 9.800$		$\chi^2 = 8.110$		$\chi^2 = 1.620$		$\chi^2 = 7.368$	
		$p < 0.01$		$p < 0.01$		$p = 0.203$		$p < 0.01$	
Proximity to a public green space	< 500m	6.0	94.0	8.3	91.7	10.6	89.4	7.3	92.7
	500m - 1km	6.0	94.0	10.3	89.7	12.1	87.9	10.3	89.7
	No garden nearby	14.9	85.1	14.9	85.1	12.2	87.8	13.5	86.5
	p-value	$\chi^2 = 7.277$		$\chi^2 = 2.953$		$\chi^2 = 0.255$		$\chi^2 = 3.159$	
		$p < 0.01$		$p = 0.228$		$p = 0.880$		$p = 0.206$	
Age	17 - 24	22.9	77.1	25.7	74.3	17.1	82.9	8.6	91.4
	25-34	3.5	96.5	7.0	93.0	12.3	87.7	6.1	93.9
	35-44	9.5	90.5	10.9	89.1	10.2	89.8	9.5	90.5
	45-54	4.9	95.1	12.3	87.7	13.9	86.1	8.2	91.8
	55-64	6.9	93.1	1.7	98.3	3.4	96.6	17.2	82.8
	65 - 81	4.0	96.0	0.0	100.0	8.0	92.0	4.0	96.0
	p-value	$\chi^2 = 17.278$		$\chi^2 = 19.727$		$\chi^2 = 6.187$		$\chi^2 = 6.881$	
		$p < 0.01$		$p < 0.01$		$p = 0.288$		$p = 0.230$	
Gender	Female	6.5	93.5	11.5	88.5	11.5	88.5	7.7	92.3
	Male	8.3	91.7	7.5	92.5	10.5	89.5	10.5	89.5
	Other[1]								
	p-value	$\chi^2 = 0.573$		$\chi^2 = 2.326$		$\chi^2 = 0.126$		$\chi^2 = 1.189$	
		$p = 0.449$		$p = 0.127$		$p = 0.722$		$p = 0.275$	
Education	Up to 9th year	6.3	93.8	18.8	81.3	6.3	93.8	12.5	87.5
	12th year	11	89	14.3	85.7	13.2	86.8	7.7	92.3
	College education	6.5	93.5	8.3	91.7	10.9	89.1	9.1	90.9
	p-value	$\chi^2 = 2.200$		$\chi^2 = 4.465$		$\chi^2 = 0.782$		$\chi^2 = 0.436$	
		$p = 0.333$		$p = 0.107$		$p = 0.676$		$p = 0.804$	
Academic background in environmental areas / ecology	Yes	6.5	93.5	8	92	14.4	85.6	9.0	91.0
	No	7.9	92.1	11	89	9.0	91.0	9.0	91.0
	p-value	$\chi^2 = 0.374$		$\chi^2 = 1.272$		$\chi^2 = 3.561$		$\chi^2 = 0.000$	
		$p = 0.541$		$p = 0.259$		$p = 0.059$		$p = 0.997$	
Professional situation	Employed	6.8	93.2	8.5	91.5	11.7	89.1	9.7	91.1
	Unemployed	1.9	98.1	9.6	90.4	3.8	96.2	11.5	88.5
	Retired	3.6	96.4	0.0	100.0	3.6	96.4	7.1	92.9
	Student	20.0	80.0	24.0	76.0	20.0	80.0	4.0	96.0
	Household	0.0	100.0	11.1	88.9	11.1	88.9	0.0	100.0
	p-value	$\chi^2 = 15.480$		$\chi^2 = 15.150$		$\chi^2 = 8.429$		$\chi^2 = 3.141$	
		$p < 0.01$		$p < 0.01$		$p = 0.077$		$p = 0.534$	

Although the majority of respondents do not use herbicides, they seem to care about their origin. Of herbicide users, only 2.08% are not interested in the origin of the herbicide (Fig. 14). Differences are found according to the area of residence, type of accommodation, existence of a garden and academic background training in the environmental area / ecology (Table 9).

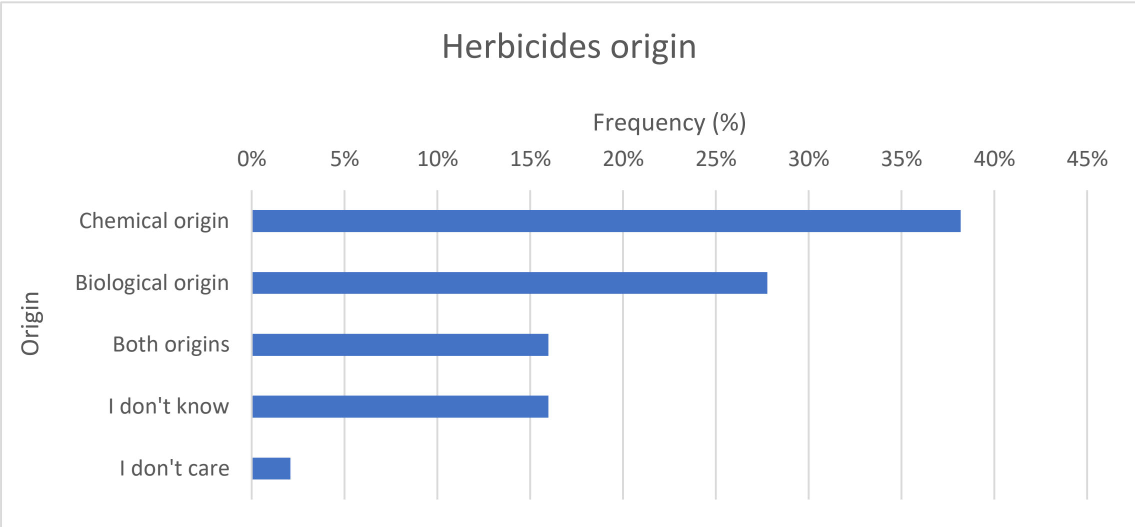

Figure 14: Frequency of herbicides origin for herbicides users.

Table 9: Origin of herbicides used by respondents, by residence, accommodation type, own a garden, proximity to public green space, age, gender, education, professional situation. [1]Statistic analysis was not taken into account due to insufficient number of responses.

Herbicides origin											
Independent variables		Chemical		Biological		Both		I don't know		I don't care	
		N	%	N	%	N	%	N	%	N	%
Area of residence	Urban area	18	34.0	15	28.3	8	15.1	10	18.9	2	3.8
	Semi-urban area	16	43.2	10	27.0	5	13.5	5	13.5	1	2.7
	Rural area	21	38.9	15	27.8	10	18.5	8	14.8	0	0.0
	p-value	χ2 = 3.283 ; *p* = 0.915									
Accommodation type	Apartment	16	32.0	18	36.0	7	14.0	7	14.0	2	4.0
	House	39	41.5	22	23.4	16	17.0	16	17.0	1	1.1
	p-value	χ2 = 4.357 ; *p* = 0.360									
Own a garden	Yes	40	38.8	27	26.2	17	16.5	18	17.5	1	1.0
	No	15	36.6	13	31.7	6	14.6	5	12.2	2	4.9
	p-value	χ2 = 3.083 ; *p* = 0.544									
Proximity to public green space	< 500m	33	40.2	24	29.3	10	12.2	13	15.9	2	2.4
	500m - 1km	10	27.0	12	32.4	9	24.3	5	13.5	1	2.7
	No garden nearby	12	48.0	4	16.0	4	16.0	5	20.0	0	0.0
	p-value	χ2 = 6.912 ; *p* = 0.546									
Age	17 - 24	4	28.6	3	21.4	5	35.7	2	14.3	0	0.0
	25-34	7	24.1	11	37.9	5	17.2	4	13.8	2	6.9
	35-44	22	50.0	8	18.2	6	13.6	7	15.9	1	2.3
	45-54	16	44.4	8	22.2	5	13.9	7	19.4	0	0.0
	55-64	6	40.0	7	46.7	1	6.7	1	6.7	0	0.0
	65 - 81	0	0.0	3	50.0	1	16.7	2	33.3	0	0.0
	p-value	χ2 = 23.798 ; *p* = 0.251									
Gender	Female	22	28.6	24	31.2	16	20.8	15	19.5	0	0.0
	Male	33	50.0	16	24.2	6	9.1	8	12.1	3	4.5
	Other[1]										
	p-value	χ2 = 12.705 ; *p* < 0.05									
Education	Up to 9th year	2	25.0	3	37.5	1	12.5	1	12.5	1	12.5
	12th year	7	24.1	10	34.5	5	17.2	7	24.1	0	0.0
	College education	46	43.0	27	25.2	17	15.9	15	14.0	2	1.9
	p-value	χ2 = 9.911 ; *p* = 0.271									
Academic background in environmental area / ecology	Yes	30	52.6	10	17.5	9	15.8	8	14.0	0	0.0
	No	25	28.7	30	34.5	14	16.1	15	17.2	3	3.4
	p-value	χ2 = 10.895 ; *p* < 0.05									
Professional situation	Employed	44	42.3	29	27.9	16	15.4	15	14.4	3	2.9
	Unemployed	5	41.7	2	16.7	3	25.0	2	16.7	0	0.0
	Retired	1	14.3	4	57.1	0	0.0	2	28.6	0	0.0
	Student	5	29.4	5	29.4	3	17.6	4	23.5	0	0.0
	Household	0	0.0	0	0.0	1	100	0	0.0	0	0.0
	p-value	χ2 = 14.079 ; *p* = 0.593									

3.4. Weed control in public space

The vast majority of respondents (94%) are aware of weed control in their municipality (Fig. 15). The relevant factors for significant differences in being aware if their local municipality performed control actions are age and academic background in environmental area / ecology. With the two youngest age groups (17 to 24 and 25 to 34) indicating less knowledge of their existence. Those with an academic background in environmental area / ecology have higher numbers than the rest of the population (Table 10).

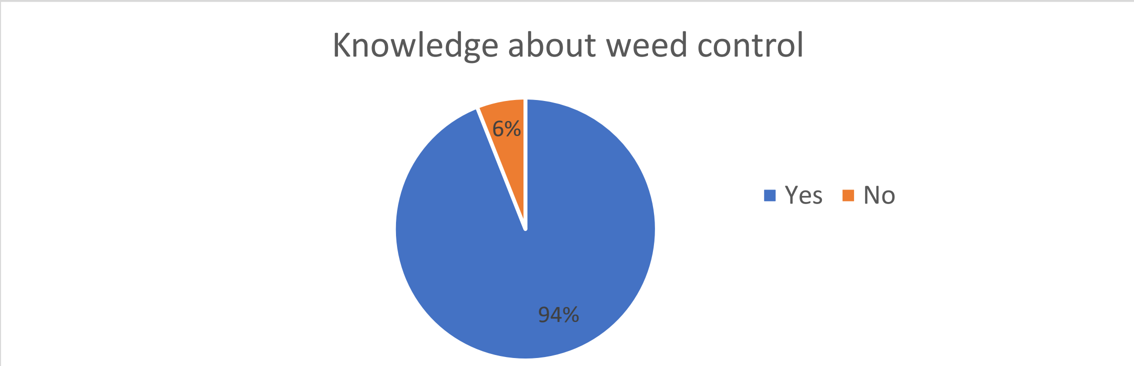

Figure 15: Overall results for respondents' knowledge about weed control in their municipality.

Overall, 31% of respondents indicated that they were usually informed of the municipality's weed control actions (Fig. 16). There are significant differences according to the variables area de residence, accommodation type, own a garden, proximity to a public green space and age (Table 10).

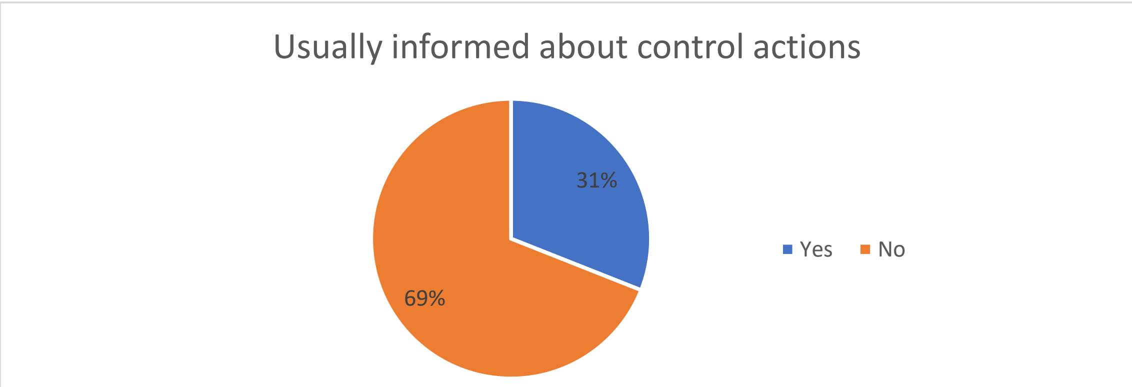

Figure 16: Respondents usually informed about control actions by the municipalities.

Table 10. Rate of knowledge and information on control measures in their municipality by residence, accommodation type, own a garden, proximity to public green space, age, gender, education, professional situation. [1]Other gender does not provide enough answers for statistical testing.

		Knowledge about weed control in municipality				Usually inform about control action			
Independent variables		Yes		No		Yes		No	
		N	%	N	%	N	%	N	%
Area of residence	Urban area	181	94.8	10	5.2	85	33.6	168	66.4
	Semi-urban area	80	95.2	4	4.8	42	38.9	66	61.1
	Rural area	97	91.5	9	8.5	25	19.2	105	80.8
	p-value	$\chi2 = 1.582$; $p = 0.438$				$\chi2 = 12.367$; $p < 0.01$			
Accommodation type	Apartment	169	93.4	12	6.6	88	36.2	155	63.8
	House	189	94.5	11	5.5	64	25.8	184	74.2
	p-value	$\chi2 = 0.214$; $p = 0.644$				$\chi2 = 6.220$; $p < 0.05$			
Garden	Yes	200	94.3	12	5.7	72	26.4	201	73.6
	No	158	93.5	11	6.5	80	36.7	138	63.3
	p-value	$\chi2 = 0.119$; $p = 0.730$				$\chi2 = 6.044$; $p < 0.05$			
Proximity to public green space	< 500m	232	95.1	12	4.9	110	36.5	191	63.5
	500m - 1km	73	92.4	6	7.6	26	22.4	90	77.6
	No garden nearby	53	91.4	5	8.6	16	21.6	58	78.4
	p-value	$\chi2 = 1.559$; $p = 0.459$				$\chi2 = 11.376$; $p < 0.01$			
Age	17 - 24	17	85.0	3	15.0	8	22.9	27	77.1
	25-34	65	86.7	10	13.3	25	21.9	89	78.1
	35-44	109	95.6	5	4.4	58	42.3	79	57.7
	45-54	103	96.3	4	3.7	32	26.2	90	73.8
	55-64	43	97.7	1	2.3	18	31.0	40	69.0
	65 - 81	21	100.0	0	0.0	11	44.0	14	56.0
	p-value	$\chi2 = 13.865$; $p < 0.05$				$\chi2 = 16.985$; $p < 0.01$			
Gender	Female	181	94.3	11	5.7	76	29.2	184	70.8
	Male	175	93.6	12	6.4	75	32.9	153	67.1
	Other1								
	p-value	$\chi2 = 0.079$; $p = 0.779$				$\chi2 = 0.763$; $p = 0.382$			
Education	Up to 9th year	12	92.3	1	7.7	7	43.8	9	56.3
	12th year	61	93.8	4	6.2	26	28.6	65	71.4
	College education	285	94.1	18	5.9	119	31.0	265	69.0
	p-value	$\chi2 = 0.069$; $p = 0.966$				$\chi2 = 1.468$; $p = 0.480$			
Academic background in environmental area / ecology	Yes	158	97.5	4	2.5	61	30.3	140	69.7
	No	200	91.3	19	8.7	91	31.4	199	68.6
	p-value	$\chi2 = 6.324$; $p < 0.05$				$\chi2 = 0.059$; $p = 0.808$			
Professional situation	Employed	259	93.5	18	6.5	114	32.4	238	67.6
	Unemployed	38	97.4	1	2.6	16	30.8	36	69.2
	Retired	24	100.0	0	0.0	11	39.3	17	60.7
	Student	29	87.9	4	12.1	9	18.0	41	82.0
	Household	8	100.0	0	0.0	2	22.2	7	77.8
	p-value	$\chi2 = 5.143$; $p = 0.273$				$\chi2 = 5.495$; $p = 0.240$			

Additionally, those who do not receive any indications about the control actions, were asked if they would like to receive this information. An overwhelming majority 92.3% indicated they were interested in knowing when the control actions are taking place (Fig. 17). On this issue, significant differences are found due to gender ($\chi^2 = 4.824$, $p < 0.05$), with women showing that they want to have more prior knowledge of control actions (Fig. 18).

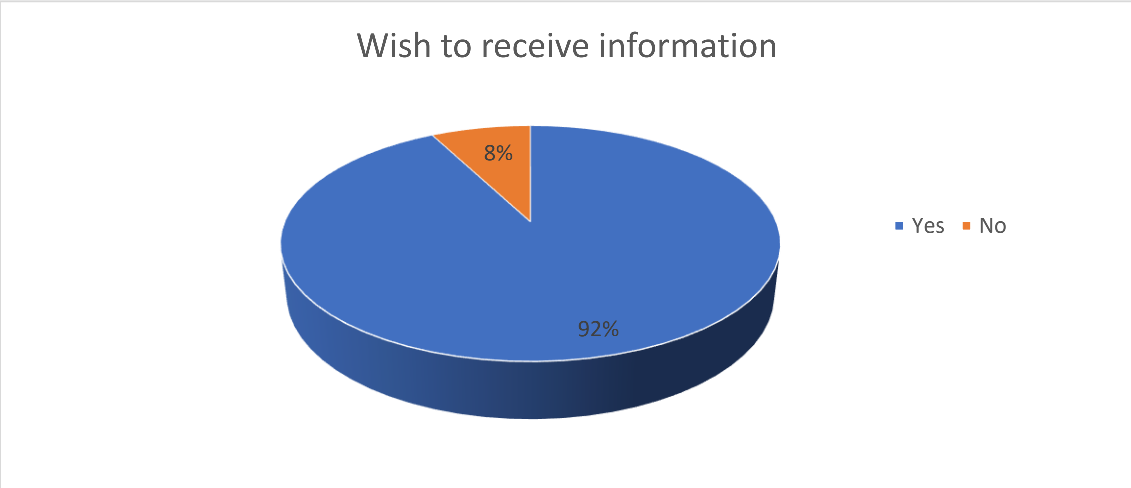

Figure 17: Resident who want to receive information on the control actions in the public area.

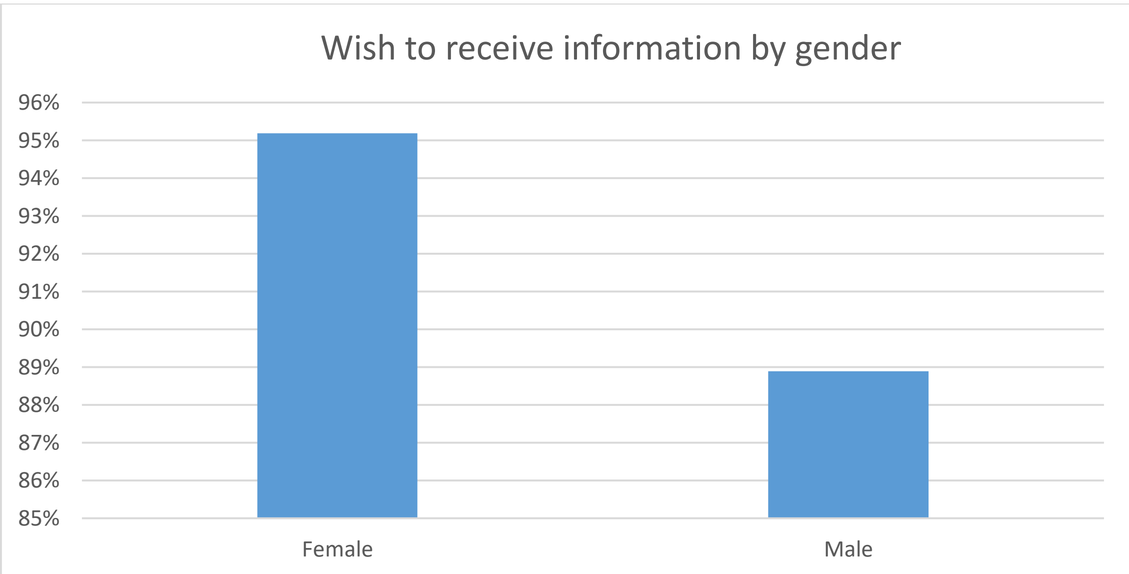

Figure 18: Want to receive information of the control actions in the public area by gender.

Participants were asked how they received information carried out in their area of residence. The results obtained indicate that the posting of a warning on the street is by far the most common mean (Fig. 19). The most relevant differences are linked to the area of residence, accommodation type, own a garden, proximity to a public green space, gender, and academic background in environmental area / ecology (Table 10).

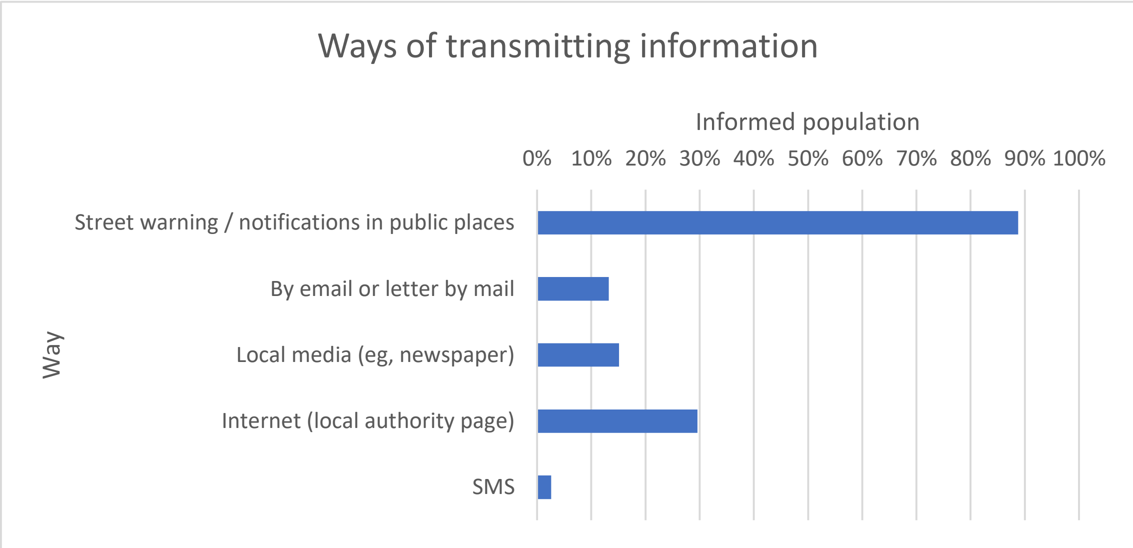

Figure 19: How residents are informed of weed control actions carried out by the municipality.

Table 11: Method of information on control measures by residence, accommodation type, own a garden, proximity to public green space, age, gender, education, professional situation. [1]Other gender does not provide enough answers for statistical testing.

Independent variables		Method of information for control measures (%)									
		Street warning		Letter mail or email		Local media		Internet		SMS	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Area of residence	Rural area	88.0	12.0	12.2	87.8	36.0	64.0	44.0	56.0	8.0	92.0
	Semi-urban area	90.5	9.5	16.7	83.3	16.7	83.3	33.3	66.7	2.4	97.6
	Urban area	88.2	11.8	11.8	88.2	8.2	91.8	23.5	76.5	1.2	98.8
	p-value	$\chi^2 = 0.162$		$\chi^2 = 0.626$		$\chi^2 = 11.703$		$\chi^2 = 4.271$		$\chi^2 = 3.525$	
		$p = 0.922$		$p = 0.731$		$p < 0.01$		$p = 0.118$		$p = 0.172$	
Accommodation type	House	87.5	12.5	12.5	87.5	8.0	92.2	23.9	76.1	0	100
	Apartment	90.6	9.4	14.1	85.9	25.0	75.0	37.5	62.5	6.3	93.8
	p-value	$\chi^2 = 0.364$		$\chi^2 = 0.079$		$\chi^2 = 8.383$		$\chi^2 = 3.306$		$\chi^2 = 5.649$	
		$p = 0.546$		$p = 0.778$		$p < 0.01$		$p = 0.069$		$p < 0.05$	
Own a garden	Yes	91.3	8.8	10.0	90.0	8.8	91.3	22.5	77.5	5.6	94.4
	No	86.1	13.9	16.7	83.3	22.2	77.8	37.5	62.5	0	100
	p-value	$\chi^2 = 1.007$		$\chi^2 = 1.474$		$\chi^2 = 5.356$		$\chi^2 = 4.091$		$\chi^2 = 4.565$	
		$p = 0.316$		$p = 0.225$		$p < 0.05$		$p < 0.05$		$p < 0.05$	
Proximity to public green space	< 500m	89.1	10.9	12.7	87.3	12.7	87.3	28.2	71.8	0.9	99.1
	500m - 1km	88.5	11.5	15.4	84.6	15.4	84.6	34.6	65.4	3.8	96.2
	No garden nearby	87.5	12.5	12.5	87.5	31.3	68.8	31.3	68.8	12.5	87.5
	p-value	$\chi^2 = 0.040$		$\chi^2 = 0.137$		$\chi^2 = 3.733$		$\chi^2 = 0.441$		$\chi^2 = 7.504$	
		$p = 0.980$		$p = 0.934$		$p = 0.155$		$p = 0.802$		$p < 0,05$	
Age	17-24	87.5	12.5	0.0	100.0	25.0	75.0	62.5	37.5	0.0	100.0
	25-34	88.0	12.0	8.0	92.0	16.0	84.0	16.0	84.0	4.0	96.0
	35-44	87.9	12.1	19.0	81.0	15.5	84.5	34.5	65.5	3.4	96.6
	45-54	93.8	6.3	12.5	87.5	6.3	93.8	25.0	75.0	3.1	96.9
	55-64	88.9	11.1	16.7	83.3	22.2	77.8	38.9	61.1	0.0	100.0
	65-81	81.8	18.2	0.0	100.0	18.2	81.8	9.1	90.9	0.0	100.0
	p-value	$\chi^2 = 1.403$		$\chi^2 = 5.379$		$\chi^2 = 3.378$		$\chi^2 = 10.328$		$\chi^2 = 1.364$	
		$p = 0.924$		$p = 0.371$		$p = 0.642$		$p = 0.066$		$p = 0.928$	
Gender	Female	82.9	17.1	14.5	85.5	14.5	85.5	26.3	73.7	3.9	96.1
	Male	94.7	5.3	10.7	89.3	16.0	84.0	32.0	68.0	1.3	98.7
	Other[1]										
	p-value	$\chi^2 = 5.236$		$\chi^2 = 0.497$		$\chi^2 = 0.068$		$\chi^2 = 0.591$		$\chi^2 = 1.000$	
		$p < 0.05$		$p = 0.481$		$p = 0.794$		$p = 0.442$		$p = 0.317$	
Education	Up to 9th year	100.0	0.0	0.0	100.0	28.6	71.4	42.9	57.1	0.0	100.0
	12th year	84.6	15.4	11.5	88.5	15.4	84.6	38.5	61.5	0.0	100.0
	College education	89.1	10.9	14.3	85.7	14.3	85.7	26.9	73.1	3.4	96.6
	p-value	$\chi^2 = 1.351$		$\chi^2 = 1.253$		$\chi^2 = 1.052$		$\chi^2 = 1.989$		$\chi^2 = 1.139$	
		$p = 0.509$		$p = 0.535$		$p = 0.591$		$p = 0.370$		$p = 0.566$	
Academic background in environmental area / ecology	Yes	96.7	3.3	11.5	88.5	11.5	88.5	24.6	75.4	3.3	96.7
	No	83.5	16.5	14.3	85.7	17.6	82.4	33.0	67.0	2.2	97.8
	p-value	$\chi^2 = 6.411$		$\chi^2 = 0.252$		$\chi^2 = 1.061$		$\chi^2 = 1.230$		$\chi^2 = 0.167$	
		$p < 0.05$		$p = 0.615$		$p = 0.303$		$p = 0.267$		$p = 0.683$	
Professional situation	Employed	89.5	10.5	15.8	84.2	14.9	85.1	31.6	68.4	2.6	97.4
	Unemployed	87.5	12.5	6.3	93.8	6.3	93.8	18.8	81.3	0.0	100.0
	Retired	81.8	18.2	0.0	100.0	18.2	81.8	9.1	90.9	0.0	100.0
	Student	88.9	11.1	11.1	88.9	33.3	66.7	55.6	44.4	11.1	88.9
	Domestic	100.0	0.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0
	p-value	$\chi^2 = 0.872$		$\chi^2 = 3.362$		$\chi^2 = 3.745$		$\chi^2 = 7.088$		$\chi^2 = 3.309$	
		$p = 0.929$		$p = 0.499$		$p = 0.442$		$p = 0.131$		$p = 0.507$	

When questioning the methods used to control weeds by municipalities, it was found that 39.9% of respondents were unaware of the methods used (Fig. 20). For those who consider themselves informed, it is found that the most perceived method is the mechanical one (Table 12).

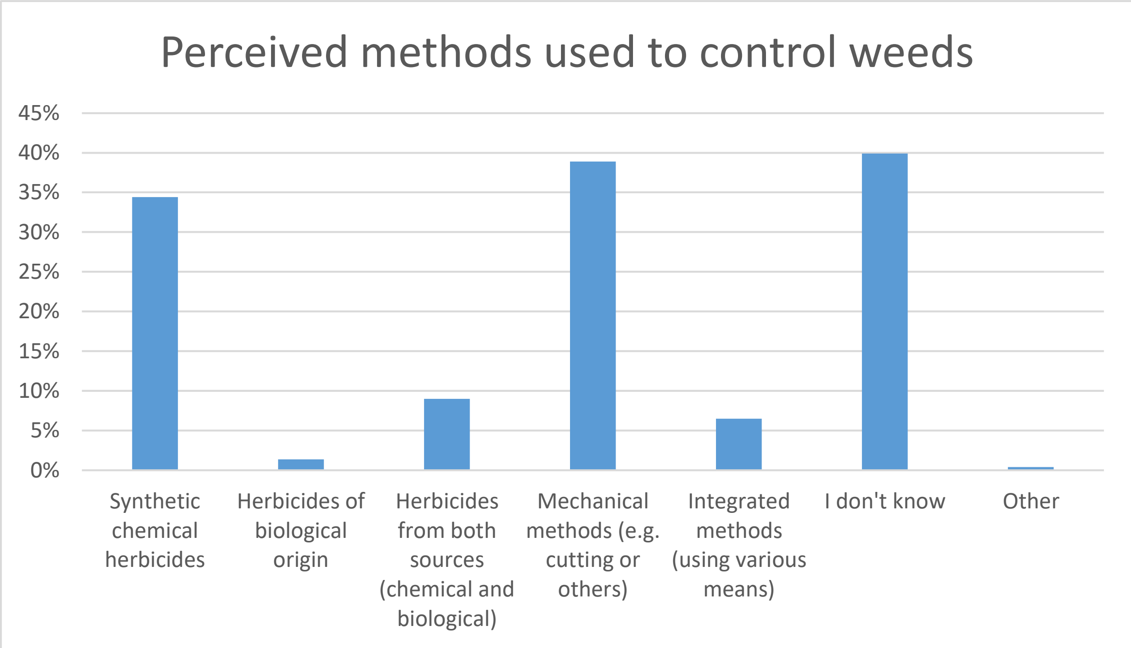

Figure 20: Perceptions of control methods used to control weeds by municipalities.

Table 12: Perception of the methods used to control weeds by municipalities by residence, accommodation type, own a garden, proximity to public green space, age, gender, education, professional situation. [1]other gender does not provide enough answers for statistical testing.

		Perception of control methods used by municipalities (%)											
Independent variables		Synthetic chemical		Biological origin		Both sources		Mechanical methods		Integrated methods		Other	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Area of residence	Urban area	57.9	42.1	3.1	96.9	10.1	89.9	66.7	33.3	13.2	86.8	0.6	99.4
	Semi-urban area	54.5	45.5	1.5	98.5	15.2	84.8	57.6	42.4	7.6	92.4	0.0	100
	Rural area	58.6	41.4	1.4	98.6	25.7	74.3	67.1	32.9	8.6	91.4	1.4	98.6
	p-value	χ^2= 0.267		χ^2= 0.888		χ^2= 9.385		χ^2= 1.920		χ^2= 2.021		χ^2= 4.486	
		p = 0.873		p = 0.62		$p < 0.01$		p = 0.383		p = 0.364		$p < 0.05$	
Accommodation type	Apartment	58.3	41.7	3.5	96.5	10.4	89.6	64.6	35.4	11.8	88.2	1.3	99
	House	56.3	43.7	1.3	98.7	19.2	80.8	64.9	35.1	9.9	90.1	0.0	100.0
	p-value	χ^2= 0.126		χ^2= 1.468		χ^2= 4.486		χ^2= 0.003		χ^2= 0.267		χ^2= 1.920	
		p = 0.723		p = 0.226		$p < 0.05$		p = 0.955		p = 0.605		p = 0.166	
Own a garden	Yes	56.5	43.5	1.2	163	17.6	82.4	65.3	34.7	10.6	89.4	1.2	98.8
	No	58.4	41.6	4.0	132	11.2	88.8	64.0	36.0	11.2	88.8	0.0	100
	p-value	χ^2= 0.110		χ^2= 2.479		χ^2= 2.359		χ^2= 0.053		χ^2= 0.028		χ^2= 1.481	
		p = 0.741		p = 0.115		p = 0.125		p = 0.818		p = 0.867		p = 0.224	
Proximity to public green space	< 500m	57.6	42.4	2.0	98.0	13.1	86.9	66.7	33.3	11.1	88.9	1.0	99.0
	500m - 1km	58.9	41.1	5.4	94.6	17.9	82.1	53.6	46.4	12.5	87.5	0.0	100
	No garden nearby	53.7	46.3	0.0	100	19.5	80.5	70.7	29.3	7.3	92.7	0.0	100
	p-value	χ^2= 0.289		χ^2= 3.256		χ^2= 1.561		χ^2= 4.027		χ^2= 0.701		χ^2= 0.986	
		p = 0.865		p = 0.196		p = 0.458		p = 0.134		p = 0.704		p = 0.611	
Age	17-24	26.7	73.3	0.0	100	40.0	60.0	73.3	26.7	20.0	80.0	0.0	100
	25-34	56.5	43.5	0.0	100	22.6	77.4	69.4	30.6	14.5	85.5	0.0	100
	35-44	56.4	43.6	2.1	97.9	16.0	84.0	63.8	36.2	10.6	89.4	0.0	100
	45-54	62.2	37.8	4.1	95.9	9.5	90.5	58.1	41.9	10.8	89.2	1.4	98.6
	55-64	68.6	31.4	2.9	97.1	2.9	97.1	65.7	34.3	2.9	97.1	2.9	97.1
	65-81	46.7	53.3	6.7	93.3	6.7	93.3	73.3	26.7	6.7	93.3	0.0	100
	p-value	χ^2= 9.028		χ^2= 4.028		χ^2= 16.938		χ^2= 3.024		χ^2= 4.748		χ^2= 4.236	
		p = 0.108		p = 0.545		$p < 0.01$		p = 0.696		p = 0.447		p = 0.516	
Gender	Female	57.6	42.4	0.0	100	15.8	84.2	64.0	36.0	10.8	89.2	0.7	99.3
	Male	56.8	43.2	4.5	95.5	14.2	85.8	65.2	34.8	11.0	89.0	0.6	99.4
	Other[1]												
	p-value	χ^2= 0.18		χ^2= 6.431		χ^2= 0.154		χ^2= 0.041		χ^2= 0.002		χ^2= 0.006	
		p = 0.893		$p < 0.05$		p = 0.695		p = 0.839		p = 0.961		p = 0.938	
Education	Up to 9th year	66.7	33.3	0.0	100	22.2	77.8	33.3	66.7	0.0	100	0.0	100
	12th year	61.7	38.3	8.5	91.5	21.3	78.7	57.4	42.6	10.6	89.4	0.0	100
	College education	56.1	43.9	1.3	98.7	13.4	86.6	67.4	32.6	11.3	88.7	0.8	99.2
	p-value	χ^2= 0.843		χ^2= 9.151		χ^2= 2.316		χ^2= 5.705		χ^2= 1.147		χ^2= 0.472	
		p = 0.656		$p < 0.05$		p = 0.314		p = 0.058		p = 0.564		p = 0.790	
Academic background in environmental area / ecology	Yes	62.8	37.2	0.7	99.3	10.2	89.8	65.7	34.3	15.3	84.7	0.0	100
	No	52.5	47.5	3.8	96.2	19.0	81.0	63.9	36.1	7.0	93.0	1.1	98.7
	p-value	χ^2= 3.146		χ^2= 2.981		χ^2= 4.445		χ^2= 0.101		χ^2= 5.311		χ^2= 1.746	
		p = 0.076		p = 0.084		$p < 0.05$		p = 0.751		$p < 0.05$		p = 0.186	
Professional situation	Employed	58.3	41.7	2.8	97.2	13.8	86.2	63.3	36.7	11.0	89.0	0.9	99.1
	Unemployed	63.0	37.0	0.0	100	22.2	77.8	63.0	37.0	7.4	92.6	0.0	100
	Retired	55.0	45.0	5.0	95.0	10.0	90.0	65.0	35.0	5.0	95.0	0.0	100
	Student	40.0	60.0	0.0	100	24.0	76.0	80.0	20.0	20.0	80.0	0.0	100
	Household	80.0	20.0	0.0	100	0.0	100	60.0	40.0	0.0	100	0.0	100
	p-value	χ^2= 4.589		χ^2= 2.117		χ^2= 4.248		χ^2= 2.835		χ^2= 3.817		χ^2= 0.711	
		p = 0.332		p = 0.714		p = 0.374		p = 0.586		p = 0.431		p = 0.950	

Then, when chemicals are perceived to be used, participants were asked if they knew which the products were. Only 39.70% answered positively to the question, indicating that the vast majority of citizens are unaware of which products are used when weeds are controlled with synthetic chemical herbicides (Fig. 21).

Figure 21: Knowledge about chemical products used by the municipality.

When evaluating the importance given to the reduction, prohibition or search for alternatives to the use of herbicides, it was found that a high number of respondents was favorable or very favorable to these solutions. To go further, the average was calculated for each of the questions, as shown in the table 14. It was found that there are significant differences (Kruskal-Wallis test) in some of the variables. The female gender presented values of importance given to each question systematically superior to the male gender (Table 13).

Respondents generally attach little importance to the use of herbicides for weed control (Fig. 22), and are divided on the costs associated with using alternatives (Fig. 27). On the other hand, the vast majority of respondents pointed out that they confer importance or great importance to the reduction or prohibition of herbicides with synthetic chemical origin, to the prohibition of glyphosate, and perceived as important the use of alternatives in an urban context (Fig. 23, 24, 25, and 26).

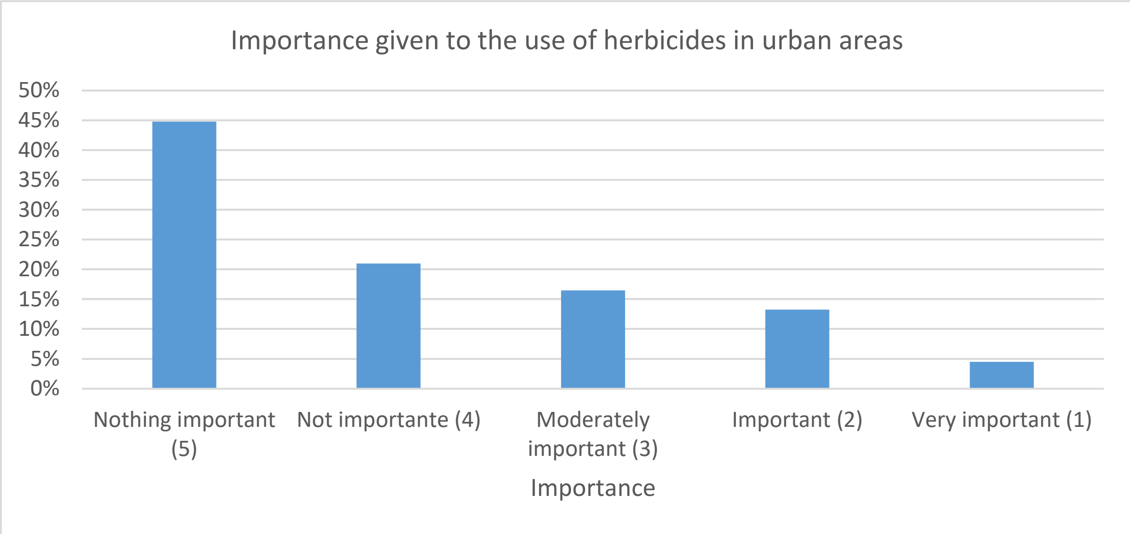

Figure 22: Importance given to the use of herbicides in the control of weeds in urban areas.

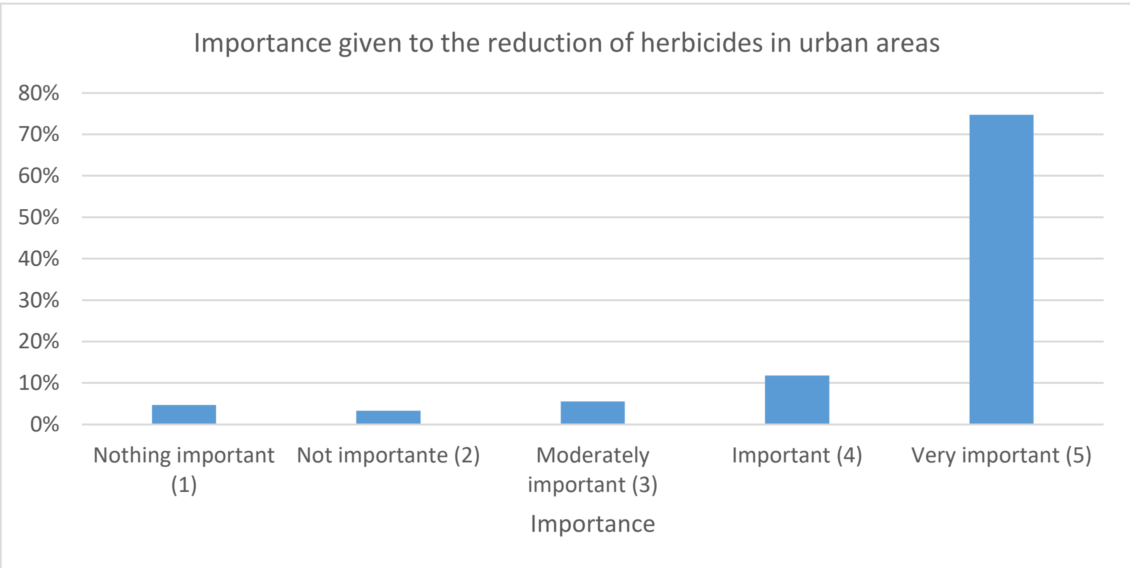

Figure 23: Importance given to the reduction of herbicides in the control of weeds in urban areas.

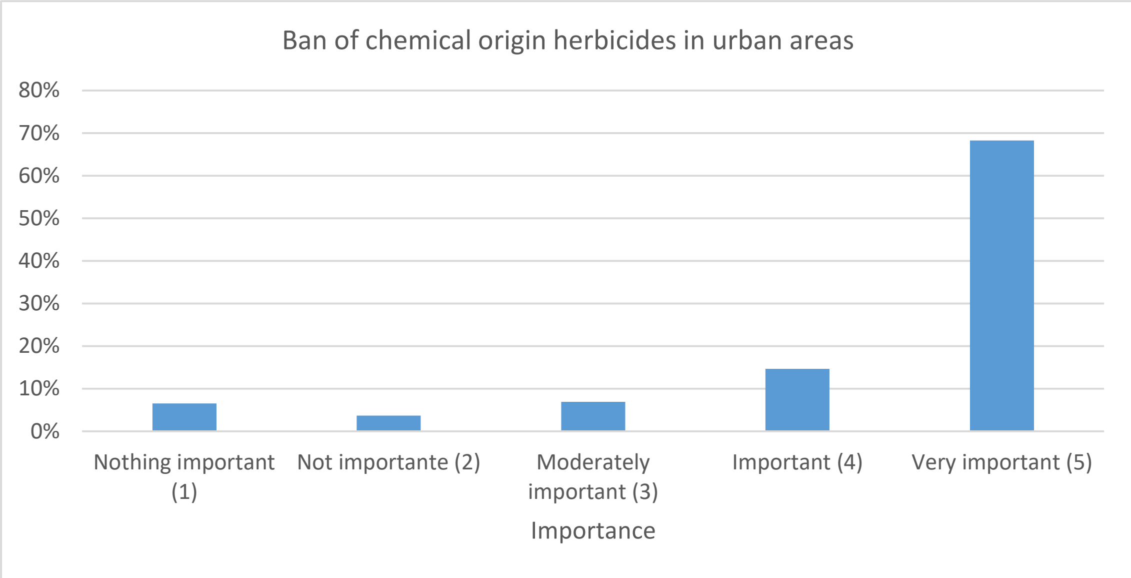

Figure 24: Importance given to the prohibition of herbicides of chemical origin in urban areas.

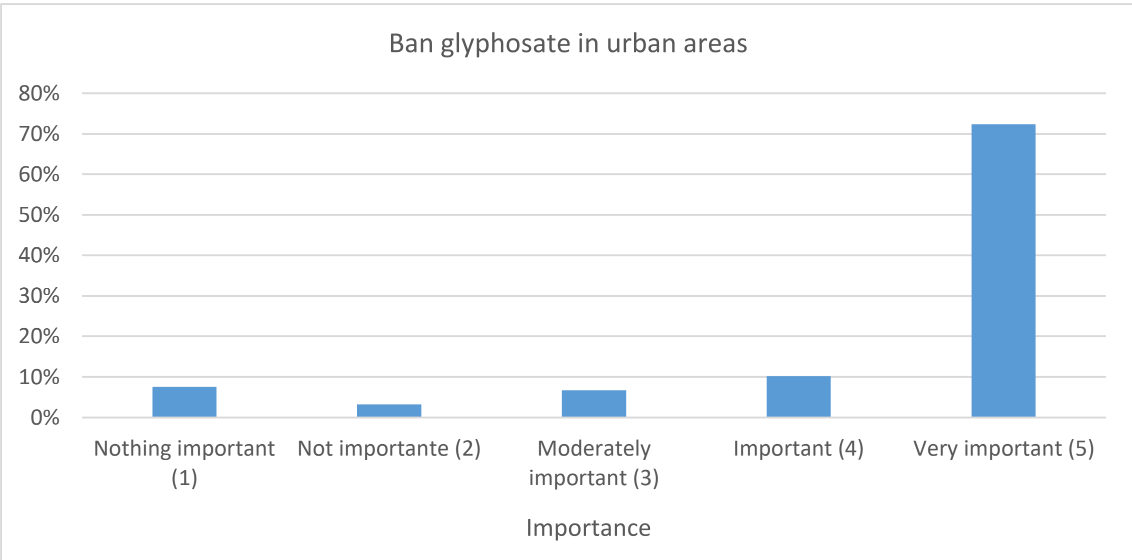

Figure 25: Importance given to ban glyphosate in urban areas.

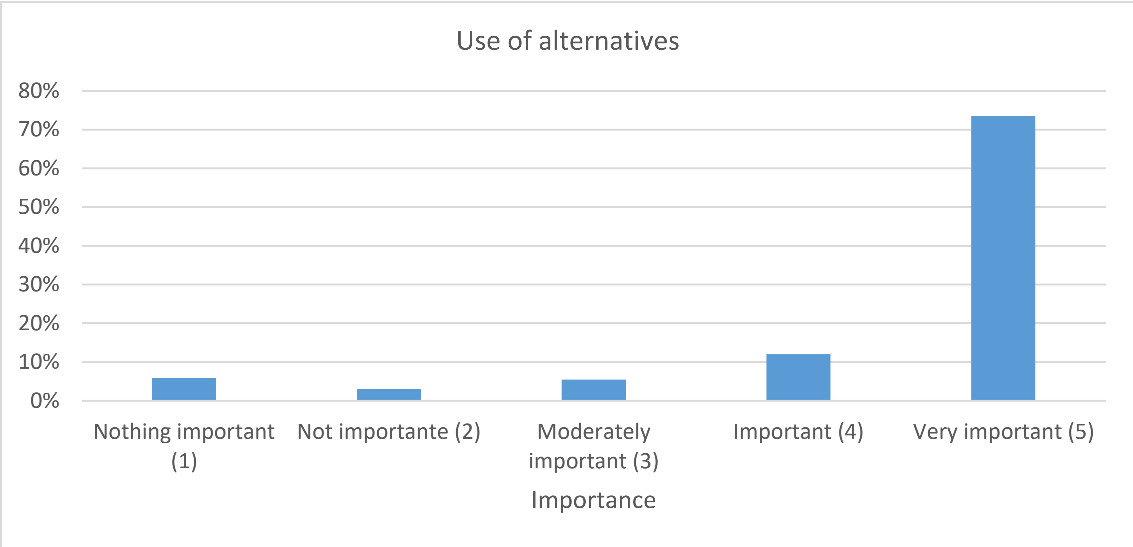

Figure 26: Importance given to the use of alternatives to herbicides in weed control.

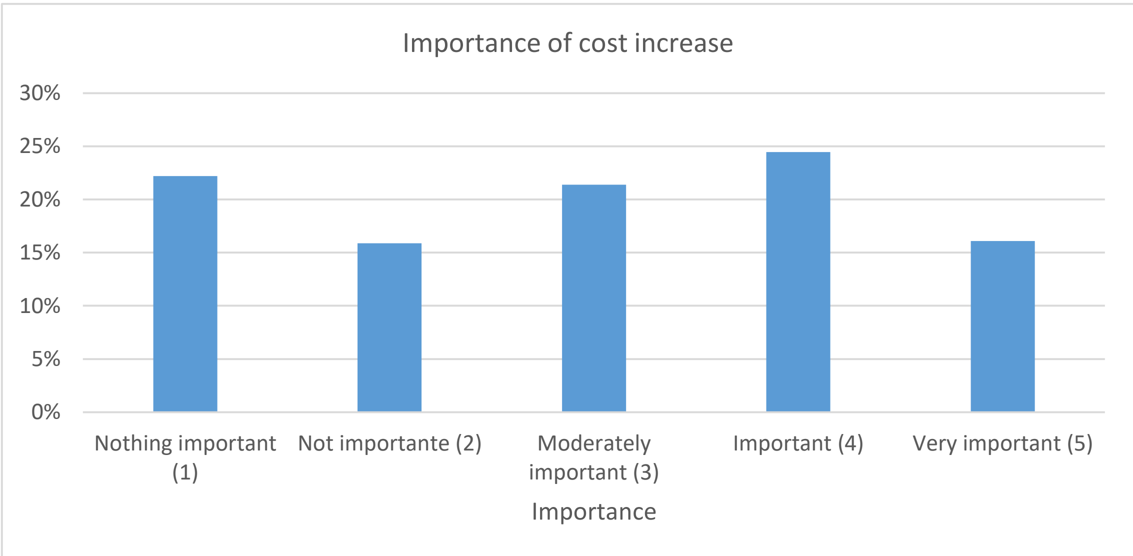

Figure 27: Importance given to the cost of using alternatives in weed control, in Lickert scale from 1 to 5.

Table 13: Mean value calculated from the Likert scale to the sentences presented in question 18, by residence, accommodation type, own a garden, proximity to public green space, age, gender, education, professional situation. [1]Statistic analysis was not taken into account due to insufficient number of responses.

Importance given to the use, reduction, prohibition, alternatives and costs of herbicides							
Independent variables		Q 18a	Q 18b	Q 18c	Q 18d	Q 18e	Q 18f
Area of residence	Urban area	3.810	4.474	4.289	4.376	4.372	2.949
	Semi-urban area	3.778	4.278	4.204	4.185	4.426	3.037
	Rural area	4.115	4.685	4.569	4.492	4.592	2.931
	p-value	$\chi2= 9.401$	$\chi2= 18.262$	$\chi2= 11.613$	$\chi2= 19.191$	$\chi2= 3.806$	$\chi2= 9.275$
		$p = 0.310$	$p < 0.05$	$p = 0.169$	$p < 0.05$	$p = 0.874$	$p = 0.320$
Accommodation type	Apartment	3.745	4.420	4.292	4.362	4.358	3.058
	House	4.020	4.552	4.395	4.367	4.524	2.871
	p-value	$\chi2= 6.226$	$\chi2= 5.579$	$\chi2= 2.009$	$\chi2= 9.208$	$\chi2= 3.501$	$\chi2= 7.763$
		$p = 0.183$	$p = 0.233$	$p = 0.734$	$p = 0.056$	$p = 0.478$	$p = 0.101$
Own a garden	Yes	3.967	4.524	4.363	4.344	4.513	2.861
	No	3.780	4.440	4.321	4.390	4.353	3.092
	p-value	$\chi2= 3.099$	$\chi2= 5.929$	$\chi2= 4.094$	$\chi2= 6.319$	$\chi2= 6.587$	$\chi2= 5.421$
		$p = 0.541$	$p = 0.205$	$p = 0.393$	$p = 0.177$	$p = 0.159$	$p = 0.247$
Proximity to public green space	< 500m	3.828	4.448	4.309	4.365	4.432	2.973
	500m - 1km	3.920	4.462	4.310	4.293	4.431	3.000
	No garden nearby	3.824	4.649	4.541	4.473	4.500	2.865
	p-value	$\chi2= 15.067$	$\chi2= 7.700$	$\chi2= 12.125$	$\chi2= 9.675$	$\chi2= 5.639$	$\chi2= 12.908$
		$p = 0.058$	$p = 0.563$	$p = 0.146$	$p = 0.289$	$p = 0.688$	$p = 0.115$
Age	17-24	3.086	4.486	4.086	4.086	4.400	3.571
	25-34	3.895	4.570	4.412	4.500	4.561	3.105
	35-44	3.788	4.394	4.241	4.234	4.387	3.066
	45-54	4.000	4.500	4.402	4.393	4.541	2.836
	55-64	4.121	4.448	4.362	4.397	4.172	2.638
	65-81	4.360	4.640	4.640	4.640	4.400	2.280
	p-value	$\chi2= 45.468$	$\chi2= 31.565$	$\chi2= 28.438$	$\chi2= 56.567$	$\chi2= 36.604$	$\chi2= 34.748$
		$p < 0.01$	$p < 0.05$	$p = 0.099$	$p < 0.001$	$p < 0.05$	$p < 0.05$
Gender	Female	3.881	4.662	4.562	4.589	4.608	3.089
	Male	3.877	4.281	4.088	4.105	4.246	2.838
	Other[1]	4.667	5.000	5.000	4.667	5.000	1.667
	p-value	$\chi2= 1.789$	$\chi2= 16.238$	$\chi2= 24.152$	$\chi2= 21.635$	$\chi2= 15.474$	$\chi2= 8.056$
		$p = 0.775$	$p < 0.01$	$p < 0.001$	$p < 0.001$	$p < 0.01$	$p = 0.090$

Q18a: Importance given to the use of herbicides in the control of weeds in urban areas. Q18b: Importance given to the reduction of herbicides in the control of weeds in urban areas. Q18c: Importance given to ban chemical origin herbicides in urban areas. Q18d: Importance given to ban glyphosate in urban areas. Q18e: Importance given to the use of alternatives to herbicides in weed control. Q18f: The perception that increased costs may be a barrier to the use of alternatives.

Table 13: continuation.

Importance given to the use, reduction, prohibition, alternatives and costs of herbicides							
Independent variables		Q 18a	Q 18b	Q 18c	Q 18d	Q 18e	Q 18f
Education	Up to 9th year	3.938	4.063	3.875	4.000	4.313	2.875
	12th year	3.824	4.506	4.418	4.385	4.550	3.011
	College education	3.896	4.500	4.346	4.375	4.422	2.956
	p-value	$\chi2= 2.834$	$\chi2= 6.922$	$\chi2= 7.633$	$\chi2= 20.381$	$\chi2= 10.591$	$\chi2= 6.661$
		$p = 0.944$	$p = 0.545$	$p = 0.470$	$p < 0.01$	$p = 0.226$	$p = 0.574$
Academic background in environmental area / ecology	Yes	3.910	4.408	4.234	4.313	4.393	3.040
	No	3.866	4.541	4.421	4.400	4.476	2.910
	p-value	$\chi2= 9.699$	$\chi2= 4.600$	$\chi2= 6.631$	$\chi2= 15.906$	$\chi2= 11.250$	$\chi2= 2.576$
		$p < 0.05$	$p = 0.331$	$p = 0.157$	$p < 0.01$	$p < 0.05$	$p = 0.631$
Professional situation	Employed	3.889	4.438	4.313	4.330	4.409	3.014
	Unemployed	4.019	4.654	4.615	4.577	4.596	2.615
	Retired	4.536	4.679	4.643	4.643	4.464	2.107
	Student	3.220	4.540	4.080	4.200	4.540	3.620
	Household	4.556	4.556	4.556	4.556	4.222	2.000
	p-value	$p < 0.05$	$\chi2= 23.111$	$\chi2= 22.394$	$\chi2= 25.922$	$\chi2= 15.172$	$\chi2= 51.768$
		$\chi2= 38.882$	$p = 0.111$	$p = 0.131$	$p = 0.055$	$p = 0.512$	$p < 0.001$

The Kruskal-wallis test was performed to analyze if there were significant differences between the group of respondents (Table 14).

Table 14: Results of the Kruskal-Wallis test for the six sentences asked in question 18. Results not statistically significant ($p > 0.05$) are not presented.

Results of the kruskal-wallis test for the variables with three or more groups, for the six items in question 18.						
Independent variables	Q 18a	Q 18b	Q 18c	Q 18d	Q 18e	Q 18f
Area of residence	$p < 0.05$	$p < 0.05$	-	-	-	-
Proximity to public green space	-	-	-	-	-	-
Age	$p < 0.001$	-	-	$p < 0.01$	-	p < 0.01
Education	-	-	-	-	-	-
Professional situation	p < 0.001	-	p < 0.05	-	-	p < 0.001

Q18a: Importance given to the use of herbicides in the control of weeds in urban areas. Q18b: Importance given to the reduction of herbicides in the control of weeds in urban areas. Q18c: Importance given to ban chemical origin herbicides in urban areas. Q18d: Importance given to ban glyphosate in urban areas. Q18e: Importance given to the use of alternatives to herbicides in weed control. Q18f: The perception that increased costs may be a barrier to the use of alternatives.

3.5. Synthetic chemical herbicides in urban areas - health and environment

When assessing the sense of security in the use of herbicides, it is observed that the overwhelming majority of respondents indicate that they are not safe (88.5%) (Fig. 28). Within variables, differences are found in gender ($\chi^2 = 24.214$, $p < 0.001$) (Fig. 29). With an opposite trend sense, people with academic background in environmental area / ecology seem to have higher values of confidence in the use of herbicides ($\chi^2 = 5.291$ $p < 0.05$) (Fig. 30).

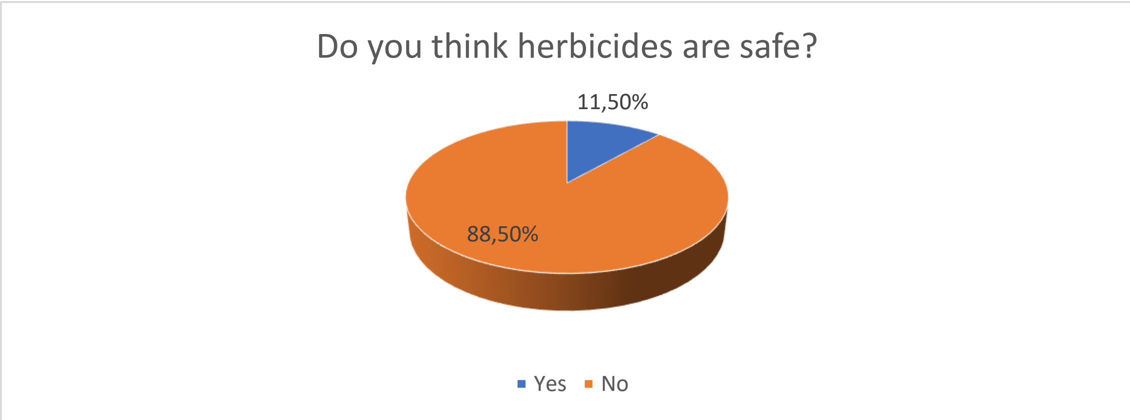

Figure 28: Overall results of herbicide safety perception.

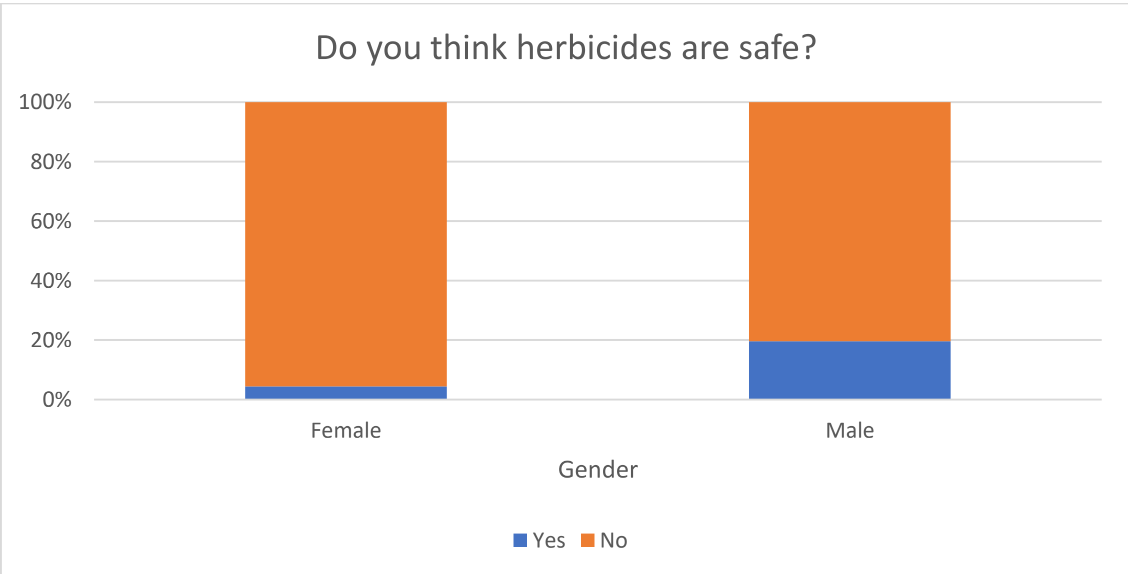

Figure 29: Perception of safety when using herbicides, by gender.

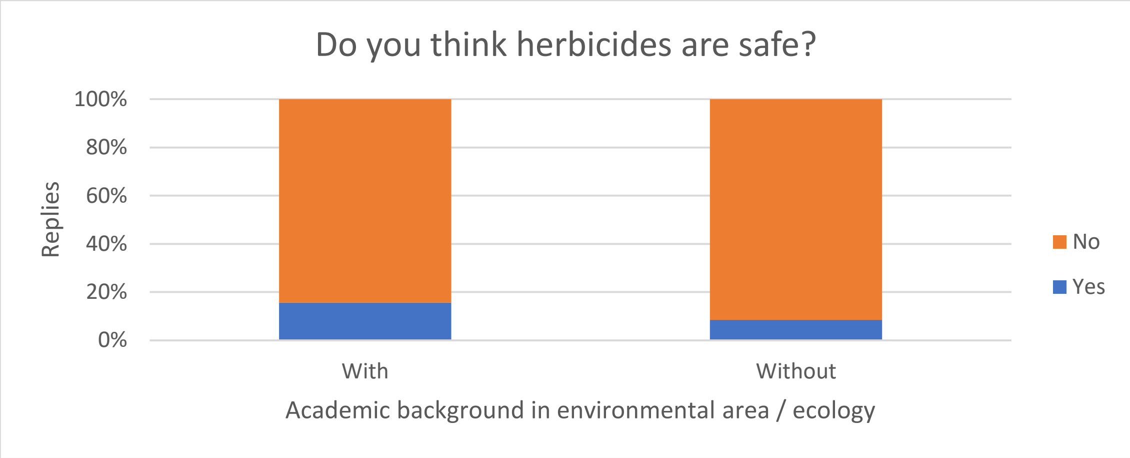

Figure 30: Perception of safety when using herbicides, by academic background in environmental area / ecology (ABE).

The information transmitted on the risks associated with herbicides was also assessed, with 67.80% of the respondents indicating that they felt properly informed. For this issue, there was a significant difference for the variables education ($\chi^2 = 6.370$, $p < 0.05$) (Fig. 31) and academic training in the environmental area / ecology ($\chi^2 = 16.410$, $p < 0.001$) (Fig. 32).

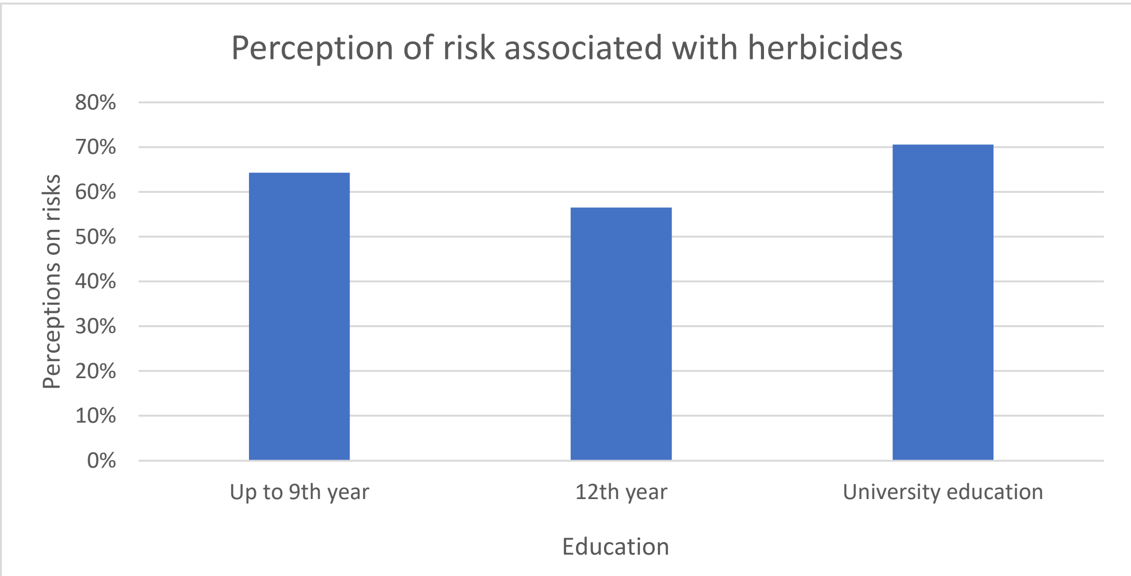

Figure 31: Perceptions on risks associated with herbicides by education level.

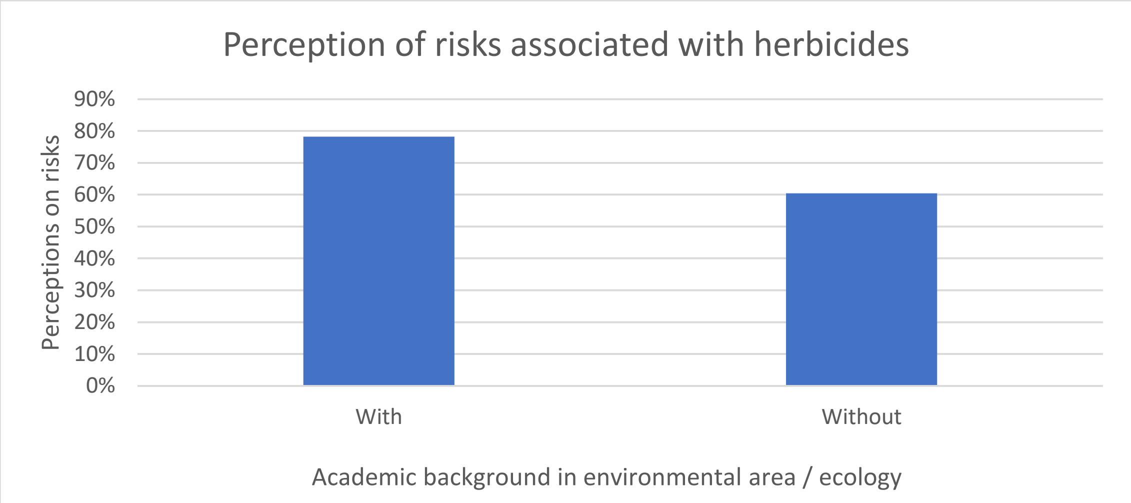

Figure 32: Perceived information on risks associated with herbicides by academic background in environmental area / ecology.

When questioned about the perception of the impacts of herbicides on health and on the environment, respondents consider them to have a high impact with all options presenting rates above 80% (Fig. 33). In this question, significant differences were observed for area of residence, age, gender, and academic background in environmental area / ecology (Table 15).

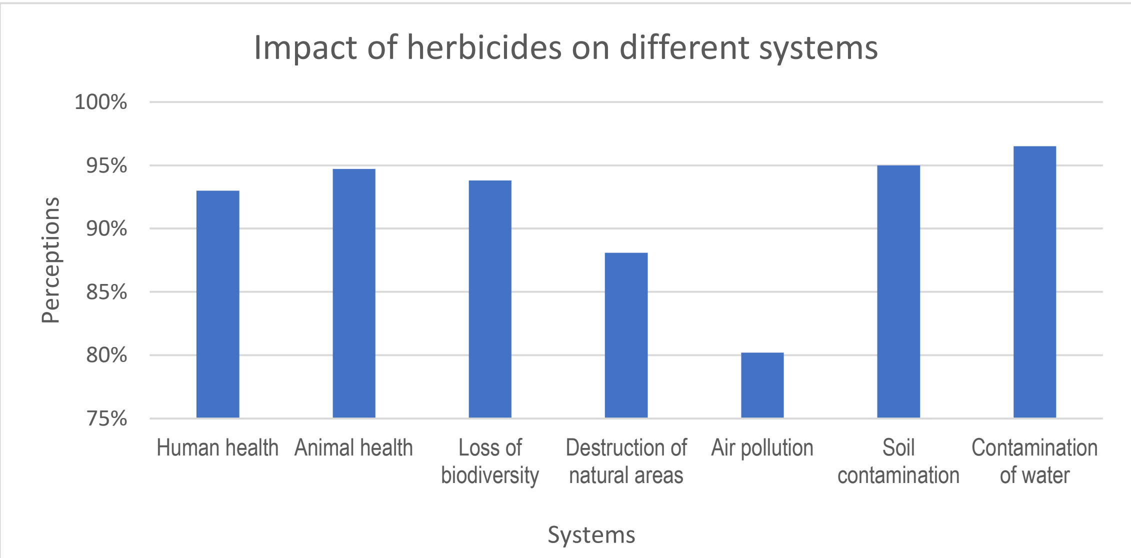

Figure 33: Perceptions on the impact of herbicides on human health, animal health, loss of biodiversity, destruction of natural habitat, air pollution, soil contamination, and contamination of water courses.

Table 15: Impacts of herbicide use on health and on the environment, by residence, accommodation type, own a garden, proximity to public green space, age, gender, education, professional situation. [1]Statistic analysis was not taken into account due to insufficient number of responses.

		Impacts of herbicides (%)													
Independent variables		Q 21a		Q 21b		Q21c		Q 21d		Q 21e		Q 21f		Q 21g	
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Area of residence	Urban area	91.4	8.6	93	7.0	92.9	7.1	87.3	12.7	76.9	23.1	94.4	5.6	96	4.0
	Semi-urban area	90.2	9.8	92.2	7.8	91.4	8.6	83.2	16.8	75.6	24.4	94.2	5.8	93.3	6.7
	Rural area	98.4	1.6	100	0.0	97.6	2.4	93.7	6.3	90.0	10.0	96.9	3.1	100	0.0
	p-value	χ^2= 8.076		χ^2= 9.774		χ^2= 4.936		χ^2= 6.196		χ^2= 9.214		χ^2= 1.345		χ^2= 8.018	
		$p < 0.05$		$p < 0.01$		$p = 0.111$		$p < 0.05$		$p < 0.05$		$p = 0.511$		$p < 0.05$	
Accommodation type	Apartment	91.4	8.6	93.6	6.4	92.6	7.4	85.8	14.2	76.9	23.1	94.1	5.9	95.4	4.6
	House	94.6	5.4	95.8	4.2	95.0	5.0	90.3	9.7	83.4	16.6	95.9	4.1	97.5	2.5
	p-value	χ^2= 1.827		χ^2= 1.218		χ^2= 1.187		χ^2= 2.242		χ^2= 2.711		χ^2= 0.811		χ^2= 1.657	
		$p = 0.208$		$p = 0.270$		$p = 0.276$		$p = 0.134$		$p = 0.100$		$p = 0.368$		$p = 0.198$	
Own a garden	Yes	94.3	5.7	95.5	4.5	95.4	4.6	90.0	10.0	84.1	15.9	95.9	4.1	97.4	2.6
	No	91.3	8.7	93.8	6.3	91.7	8.3	85.7	14.3	75.3	24.7	93.9	6.1	95.3	4.7
	p-value	χ^2= 1.609		χ^2= 0.690		χ^2= 2.711		χ^2= 2.043		χ^2= 4.844		χ^2= 0.939		χ^2= 1.491	
		$p = 0.205$		$p = 0.406$		$p = 0.100$		$p = 0.153$		$p < 0.05$		$p = 0.333$		$p = 0.222$	
Proximity to public green space	< 500m	91.7	8.3	93.8	6.3	94.1	5.9	87.6	12.4	78.3	21.7	93.9	6.1	95.9	4.1
	500m - 1km	93.8	6.2	94.7	5.3	91.0	9.0	84.7	15.3	80.8	19.2	95.6	4.4	95.7	4.3
	No garden nearby	97.2	2.8	98.6	1.4	97.1	2.9	95.8	4.2	86.9	13.1	98.6	1.4	100	0.0
	p-value	χ^2= 2.879		χ^2= 2.719		χ^2= 2.856		χ^2= 5.311		χ^2= 2.307		χ^2= 2.847		χ^2= 3.126	
		$p = 0.237$		$p = 0.257$		$p = 0.240$		$p = 0.070$		$p = 0.316$		$p = 0.241$		$p = 0.210$	
Age	17-25	97.0	3.0	100	0.0	88.6	11.4	77.1	22.9	72.7	27.3	91.4	8.6	100	0.0
	25-34	95.3	4.7	96.3	3.7	96.3	3.7	90.5	9.5	81.3	18.8	98.2	1.8	98.2	1.8
	35-44	86.7	13.3	88.8	11.2	91.7	8.3	84.5	15.5	76.9	23.1	92.5	7.5	94.1	5.9
	45-54	92.3	7.7	94.8	5.2	94.0	6.0	90.4	9.6	82.9	17.1	93.3	6.7	94.1	5.9
	55-64	100	0.0	100	0.0	96.4	3.6	90.9	9.1	76.6	23.4	98.2	1.8	100	0.0
	65-81	100	0.0	100	0.0	95.7	4.3	96.0	4.0	100	0.0	100	0.0	100	0.0
	p-value	χ^2= 16.239		χ^2= 16.278		χ^2= 4.515		χ^2= 8.700		χ^2= 8.289		χ^2= 8.312		χ^2= 9.371	
		$p < 0.01$		$p < 0.01$		$p = 0.478$		$p = 0.122$		$p = 0.141$		$p = 0.140$		$p = 0.095$	
Gender	Female	96.4	3.6	98.0	2.0	96.4	3.6	94.0	6.0	90.5	9.5	96.9	3.1	97.7	2.3
	Male	88.9	11.1	90.8	9.2	90.7	9.3	81.2	18.8	67.6	32.4	92.7	7.3	95.0	5.0
	Other[1]														
	p-value	χ^2= 10.72		χ^2= 12.159		χ^2= 6.612		χ^2= 17.675		χ^2= 32.940		χ^2= 4.293		χ^2= 2.450	
		$p < 0.01$		$p < 0.001$		$p < 0.05$		$p < 0.001$		$p < 0.001$		$p < 0.05$		$p = 0.118$	

Q21a: Human health. Q21b: Animal health. Q21c: Loss of biodiversity. Q21d: Destruction of natural areas. Q21e: Air pollution. Q21f: Soil contamination Q21g: Contamination of water courses.

Table 15 (continuation).

Independent variables		Impacts of herbicides (%) Q 21a Yes	No	Q 21b Yes	No	Q21c Yes	No	Q 21d Yes	No	Q 21e Yes	No	Q 21f Yes	No	Q 21g Yes	No
Education	Up to 9th year	93.8	6.3	93.8	6.3	93.8	6.3	93.8	6.3	93.3	6.7	100	0.0	93.8	6.3
	12th year	97.7	2.3	100	0.0	94.2	5.8	90.5	9.5	85.3	14.7	96.6	3.4	97.7	2.3
	College education	91.9	8.1	93.5	6.5	93.7	6.3	87.4	12.6	78.3	21.7	94.4	5.6	96.3	3.7
	p-value	$\chi2= 3.583$		$\chi2= 5.867$		$\chi2= 0.025$		$\chi2= 1.131$		$\chi2= 3.555$		$\chi2= 1.541$		$\chi2= 0.769$	
		$p = 0.167$		$p = 0.053$		$p = 0.988$		$p = 0.568$		$p = 0.169$		$p = 0.463$		$p = 0.681$	
Academic background in environmental area / ecology	Yes	90.3	9.7	91.9	8.1	93.9	6.1	85.5	14.5	74.1	25.9	92.4	7.6	94.9	5.1
	No	95.0	5.0	96.7	3.3	93.8	6.2	90.0	10.0	84.3	15.7	96.8	3.2	97.5	2.5
	p-value	$\chi2= 3.914$		$\chi2= 5.426$		$\chi2= 0.002$		$\chi2= 2.228$		$\chi2= 6.387$		$\chi2= 4.707$		$\chi2= 2.246$	
		$p < 0.05$		$p < 0.05$		$p = 0.963$		$p = 0.136$		$p < 0.05$		$p < 0.05$		$p = 0.134$	
Professional situation	Employed	91.8	8.2	93.3	6.7	93.5	6.5	89.2	10.8	78.9	21.1	93.9	6.1	95.4	4.6
	Unemployed	98.0	2.0	100	0.0	97.9	2.1	89.4	10.6	88.9	11.1	100	0.0	100	0.0
	Retired	100	0.0	100	0.0	96.2	3.8	96.4	3.6	100	0.0	100	0.0	100	0.0
	Student	91.5	8.5	95.7	4.3	90.0	10.0	73.5	26.5	68.3	31.7	94.0	6.0	98.0	2.0
	Household	100	0.0	100	0.0	100	0.0	100	0.0	87.5	12.5	100	0.0	100	0.0
	p-value	$\chi2= 5.608$		$\chi2= 6.203$		$\chi2= 3.561$		$\chi2= 13.407$		$\chi2= 12.119$		$\chi2= 5.515$		$\chi2= 4.682$	
		$p = 0.230$		$p = 0.184$		$p = 0.469$		$p < 0.01$		$p < 0.05$		$p = 0.238$		$p = 0.322$	

3.6. A little more about the respondents

When asked if they are members of an environmental non-governmental organization (eNGO), 15.7% of the participants respond positively. It is also found that there are significant differences for gender ($\chi^2 = 4.415$, $p < 0.05$) (Fig. 34) and academic background in environmental area / ecology ($\chi^2 = 14.536$, $p < 0.001$) (Fig. 35).

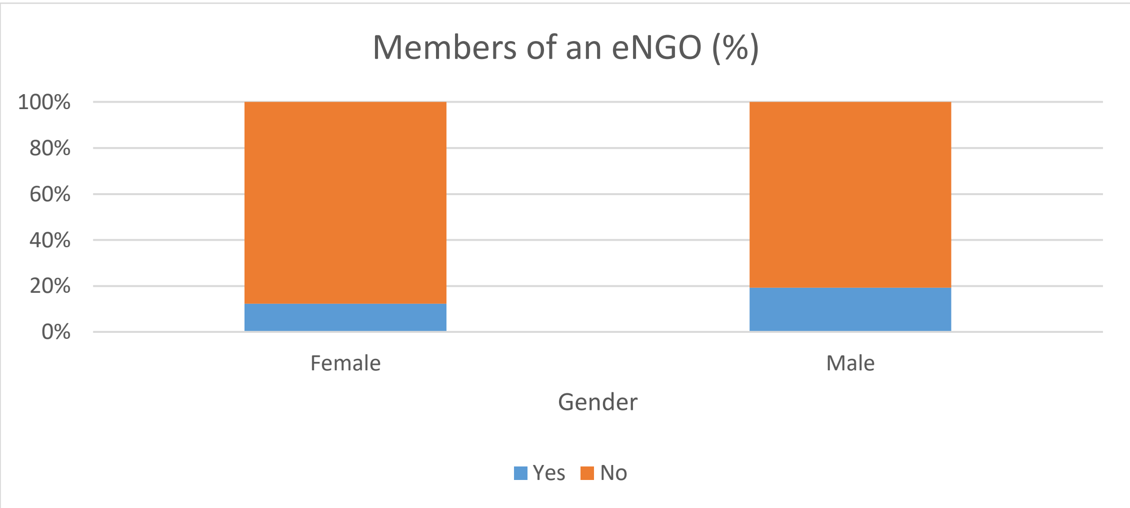

Figure 34: Members of an eNGO by gender.

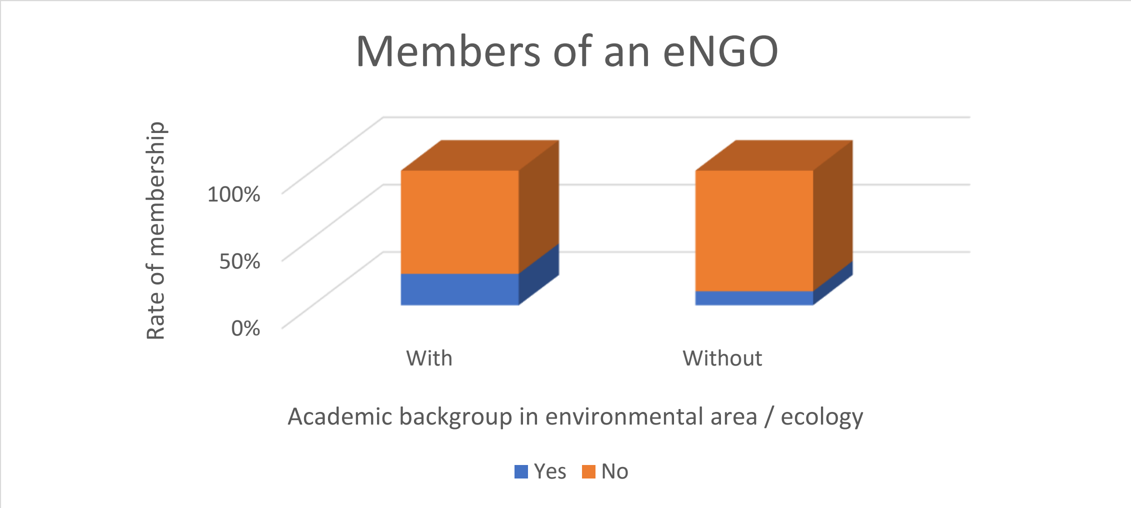

Figure 35: Members of an eNGO by academic background in environmental area / ecology.

When asked if the protection of the environment is relevant to them, 98.8% answered positively to the question. Regarding the importance given to the protection of biodiversity, a value of 99.2% is obtained, indicating that they are concerned with this topic. At this point, the only significant difference is due to the gender of the participants ($\chi^2 = 4.599$, $p < 0.05$) (Fig. 36). On the other hand, it is found that 94.7% of respondents indicated that they give importance to the topic addressed in the survey.

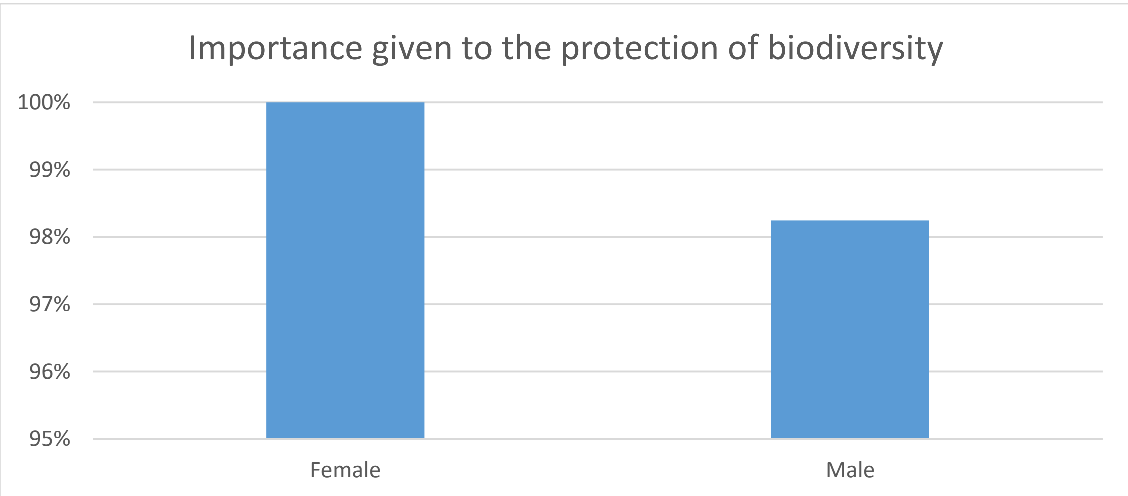

Figure 36: Importance given to the protection of biodiversity by gender.

We asked to participants to evaluate their knowledge related about the topic addressed in this study, using a scale of 1 to 5. About 40% of the respondents consider themselves to have reasonable knowledge, but an important subsample consider to have a vague or very vague knowledge (Fig 27 and 38). There are significant differences for the variables gender (χ^2 = 9.514, $p < 0.05$) (Fig. 37), and academic background in the area of the environment / ecology (χ^2 = 52.092, $p < 0.001$) (Fig. 38).

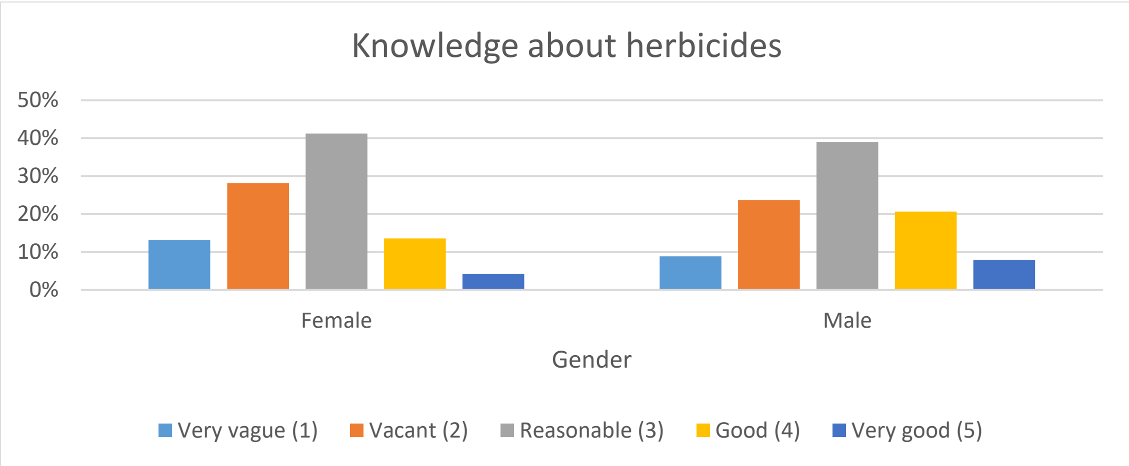

Figure 37: Knowledge about the topic addressed in the study by gender.

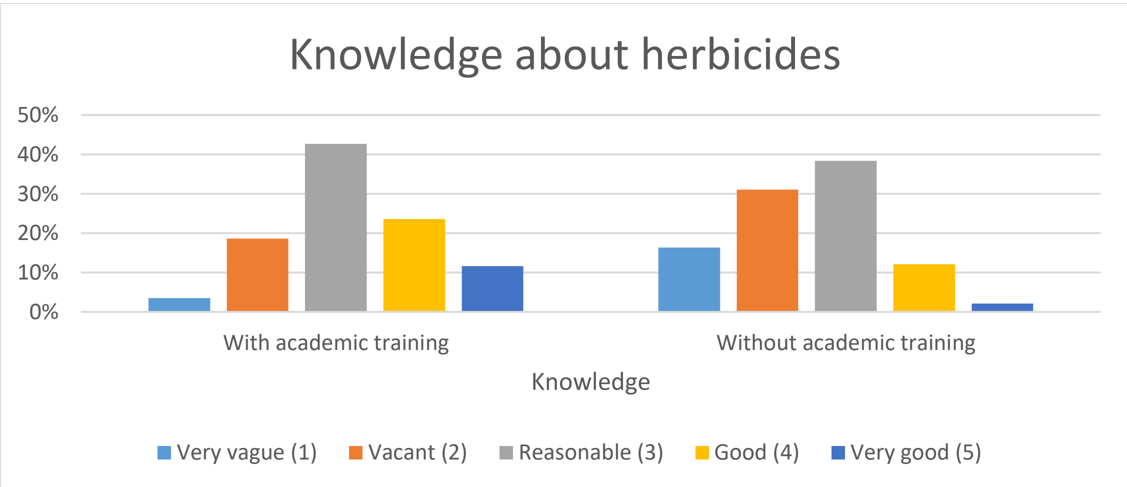

Figure 38: Knowledge about the topic addressed in the study by academic background on environmental area / ecology.

When inquiring about the population's knowledge of a project, activity or association related to weed control, it is found that 27.7% of respondents respond positively. For this issue, it is found to be crucial to have academic background in environmental area / ecology (χ^2 = 27.536, $p < 0.001$) with 40.3% of participating respondents with ABE indicating to know a project, activity or association for only 18.97% those without ABE.

4. Discussion and conclusion

There has been an increase in public concern over the impacts of herbicides on human health and the environment, highlighting the need to study more deeply the issue and addressing the problem in an integrated, multidisciplinary way (Ahmed et al., 2011; Remoundou et al., 2014).

4.1. Citizens' perceptions regarding weeds in their areas of residence

The perceptions of respondents regarding the presence of weeds in pedestrian walks, and paths; sidewalks, and road separators; parks, and gardens; roundabouts; walls or rooftops was high (60%) (up to 80%), (Fig. 9) and was even higher in the case of respondents living in less urbanized areas (Table 5). It is also found that respondents living in houses and having a garden have higher perception values in noting weeds in four locations (pedestrian walks and paths; sidewalks and separators; roundabouts; wall or roof) (Table 5). One of the possible reasons for these results is that having a house with a garden increases the perception of the presence of weeds possibly because they have to worry about weed control around their house, in contrast to residents that live in apartments and do not have the same need as evidenced by a similar previous work (Hirsch & Baxter, 2011). The constant maintenance by other entities of public parks and gardens may reduce the perception of the presence of weeds (Hirsch & Baxter, 2011), or these may simply be seen as the habitats where plants are found, with no distinction between weeds and other vegetation.

Respondents consider important not to see weeds in the locations proposed by this study (pedestrian walks and paths; sidewalks and road separators; parks and gardens; roundabouts; walls or rooftop). More responses are given for the pedestrian walks and paths (64%) and walls or rooftops (63.4%), and less importance is given to control in roundabouts (47.9%) (Table 6). These results indicate that there may be a logic of functionality attributed to weed control, such as traffic of vehicles or people, or to the maintenance of built structures such as walls and rooftops. This difference between the perceptions of the presence of weeds and the need to control them may be due to the fact that part of the population perceives roadside vegetation as something beneficial, whether for aesthetic reasons or to increase biodiversity (Weber et al., 2013).

Significant differences exist for the variable age and academic background in environmental area / ecology (Table 6). Respondents from 17 to 24 years old indicate a much greater need for control than the other age groups, with differences of more than 18% in all proposed locations. This may be due to a more utilitarian or radical view of weed control, perceiving weed control as essential for conveying the image of clean and cared-for places (Rupprecht, 2017). In the case of respondents with academic background in environmental area / ecology, the opposite phenomenon is observed, systematically pointing to a reduced need for this control. The reason behind these findings may be due to a greater awareness or understanding of the preservation of green spots/sites that can contribute to the increase of biodiversity, especially in more urbanized areas where the occurrence of vegetation, whether spontaneous or planted, tends to be lower. Previous works have shown that environmental education in these areas is essential to raise awareness to the need to preserve biodiversity (Weber et al., 2013; Yapici et al., 2017; Carmi & Alkaher, 2020).

4.2. Use of herbicides

The results obtained indicate that many respondents know at least one herbicide (88%) (Table 7). Having a garden or academic background in environment area / ecology seems to be relevant to recognize of at least one herbicide. Having a garden may infer having to use more herbicides, which is also evidenced by this study (Table 8). This has also been shown in other studies (Hirsch & Baxter, 2011; Ríos-González et al., 2013).

When asked about the knowledge of a specific herbicide, glyphosate, the value obtained is also very high (88.7%) (Table 7). In the younger population (under 25) and students, the knowledge of this substance is much lower than among the rest of the population (just 62% and 73%, respectively). These results can be explained by the need to have experience in dealing with herbicides, acquired by using them throughout life, for example, through formal education (Ríos-González et al., 2013). According to the aforementioned author, most people with knowledge about herbicides, have acquired it through using them out of necessity, either for personal or professional reasons. Formal knowledge is only acquired later, in specific training courses (e.g. for operators) or formal education for academic, technicians and trainers as described by Ríos-González et al. (2013). This work also supports this finding as there is a positive relationship between a higher level of education and academic background in environmental area / ecology, with the knowledge about what glyphosate is. Other researchers have also found similar findings (Yapici et al., 2017; Carmi & Alkaher, 2020).

When asked about how often they use herbicides, a large majority of respondents indicate that they never use these products (Fig. 12). Our study indicates that the main differences are found in the area of residence, typology of accommodation and owning a garden (Table 8). The target population of this study is not specifically aimed at professionals who need to use herbicides (e.g. farmers) in their area of work, which may explain these lower values. Respondents from semi-urban and rural areas seem to use herbicides more often. In these areas is more frequent to find citizens living in houses and having gardens or vegetable gardens.

Respondents were also asked about if herbicides were applied in their gardens, vegetable gardens, agriculture or hard surfaces. There was a large variation in the responses of students and people under 25 years old, two interrelated variables that appear with a much higher rate of herbicide use in gardens and vegetable gardens. Our results indicate that respondents under 25 years old and students know less about herbicide products or glyphosate, which may be due to what they understand being applied around them, by their parents for example, or simply represents that paid less attention to this question.

When analyzing the percentage of the respondents that use synthetic chemical herbicides compared to other sources, such as those of biological origin, it is observed that a large part of the sample (38.2%), still prefers the chemical origin. When analyzing the results obtained on the origin of the herbicides, it is found significant differences for the variables gender and academic training in the environmental/ ecology area. In the case of gender, men show higher values (50%) on the use of products with chemical origin, to the detriment of other alternatives, while for women, the main origin of herbicides is biological (31%), but closely followed by the chemical option and both origins (Table 9). This result may be due to a higher health or environmental concerns demonstrated by women in previous studies (Cabrera & Leckie, 2009; Ahmed et al., 2011; Remoundou et al. 2014; Kunin & Lucero, 2020). Women use more protective equipment and pay more attention to safety when handling herbicides. Women tend to see weed control and the use of pesticides as less essential (Cabrera & Leckie, 2009; Hirsch & Baxter, 2011), seek to use fewer herbicides (Ahmed et al., 2011; Hirsch & Baxter, 2011).

Respondents with an environmental area/ ecology background indicate they use more chemically derived herbicides than those without that background. These results may be due to two factors. The first is that having an academic degree in the area in question may induce a feeling of confidence in the products, either by their constant use or by the optimism of the effects obtained (Dentzman et al., 2016). On the other hand, the fact that a person has more training in the area may translate into more reliable answers, because they perceived themselves to have more knowledge about the products they use, leading to a greater confidence in their personal knowledge and on a difference in the perception of the benefits and risks of using a certain product. However, belonging to this group may also reflect greater concern in the choice of products and their conscious use (Mobley et al., 2010; Yapici et al., 2017).

4.3. Weed control in public spaces

Our survey shows that a vast majority of the population perceives that there is public weed control in their areas of residence (94%). The only significant difference is related to the academic background in the area of environment / ecology. Respondents belonging to this group seems to be slightly more aware about weed control actions. Environmental education can once again be a relevant factor in changing peoples' perceptions, making them more aware and attentive to issues related to the environment (Yapici et al., 2017; Carmi & Alkaher, 2020).

Overall, 31% of the respondents indicate that they receive prior information on control actions by local authorities displayed in street warning/notification in public spaces (Fig. 16). The significant differences are related to the characteristics of the type of accommodation, area of residence, and age (Table 10). Living in a more urbanized area seems to be a decisive factor to get more information about the control actions by the municipalities. Consequently, those who live in apartments, and people without a garden, have also higher rates of information about control actions. Another important factor is the proximity to green spaces, with those who live within 500 meters claiming to be the most informed about the control actions. Finally, the age groups 35 to 44 and over 65 years old have higher rates of perception of control actions by the authorities.

The vast majority of respondents' groups indicate that they would like to be informed about the control actions performed by the municipality, and the only significant difference is due to gender, with women indicating more often than men, that wish to receive prior information on these actions. This issue may be related to a greater concern with health and welfare issues by this group (Flynn et al., 1994; McCrigh et al., 2010; Ahmed et al., 2011; Hirsch & Baxter, 2011; Remoundou et al. 2014; Kunin & Lucero, 2020). It also may be related to a greater concern on the part of women about the dangers of herbicides, and the greater need for the implementation of preventive measures to avoid any harm if they are used (Cabrera & Leckie, 2009; Remoundou et al. 2014; Kunin & Lucero, 2020). The greater concern about the risks associated with the use of these products may thus translate into a greater intention to receive more information about their application in their area of residence.

The communication about control actions by warning/notification on the street stands out for being the most selected means respondents knew about control action (Fig. 19). For the form of communication warning/notification of the street, the main significant differences are observed in gender and academic background in environmental area / ecology. Having an academic background in environmental area / ecology may somehow influence them in paying more attention to the issue of control actions or weed presence (Table 11). Despite not always being able to link between environmental education and greater participation in activities or groups related to the theme (Yapici et al., 2017), our results show an opposite trend and this group show to be related to a greater civic participation in issues related to the protection of the environment, like a eNGO which can support this awareness values. As for the differences between female and male groups, the results may be due to greater attention paid to street warnings or notifications, as well as greater civic participation (Cicognani et al., 2011; Voicu & Voicu, 2016), whether in the form of associativism (member of an eNGO) as found in this work.

For the remaining forms of communication, it is found that the decisive factors for greater awareness of control actions are: living in an urban area, living in an apartment, and not having a garden. These respondents are more likely to learn about the control actions through local media, internet or receiving SMS texts. We can further speculate that the urban population is somehow more involved or concerned on herbicide application on public roads, more abundant the their environment when compared with rural areas.

Overall, between the five methods used to control weeds by the municipalities- synthetic chemical, biological origin, both sources, mechanical methods, and integrated methods, results are very homogeneous, with emphasis on a greater perception to the use of chemical control and mechanical control by the local authorities. Significant differences in the perceptions of different groups of respondents on the methods used to control weeds by the municipalities is mainly related with herbicides of both origins. When we look at the area of residence, more respondents living in rural areas (and consequently those living in houses) select more often the option both origins, when compared to the other two groups, which may reflect a greater proximity to the places where the various herbicides are applied.

Those with an academic background environmental area / ecology select less times the option both origin and refer that the municipality use more herbicides with chemical origin. The studies on environmental education point to a greater knowledge and awareness of the impacts of herbicides for people with this background (Carmi & Alkaher, 2020), which may also be the case in this study. This group of respondents may be more familiar with these topics and be more skilled to distinguish the type of herbicides used.

This study indicates that few people think they know which products (of chemical origin) are used in weed control (Figure 21). This result is in line with the low rate of knowledge of control actions (Figure 15) and may be related to the fact that they also did not know which methods were used (Figure 20). Men indicate more knowledge of the substances used. In our study, more men claim to belong to an eNGO than women. If we consider that it may be a proxy for their level of involvement in the community and civic participation, as stated by Cicognani et al. (2011); Voicu & Voicu (2016), then will be able to recognize more easily these products.

As for age, the results are in agreement with other results obtained by other authors (Peterson, 2000; Dawson, 2007) which is that there is a high lack of knowledge or interest in the subject of pesticides, or related biotechnology topics, among the younger age groups Despite being more concerned about environmental impacts on ecosystems and nature, younger people have lower levels of holistic understanding about sustainability than the older population (Hill & Lee, 2012).

Overall, respondents do not believe it is essential to use chemical herbicides to control weeds in urban environments (Figure 22) and consider it important or very important to reduce or even ban the use these products, including glyphosate, favoring alternatives with less environmental impacts. On the question if the increase in costs related to the search for alternatives to synthetic chemical herbicides is an obstacle to their use, the answers show greater dispersion of opinion (Figure 27). People want, in fact, to reduce or ban the use of chemical herbicides in urban environments, preferring the use of other weed control alternatives, especially when it comes to banning glyphosate.

Despite not statistically significant, people living in rural areas show to want more the reduction of herbicides of chemical origin, and the ban on glyphosate in urban environments (Tables 13, and 14). Previous works indicate there are fewer differences between the rural and urban areas on issues of environmental concern (Coppin et al., 2002; Huddart-Kennedy et al., 2009) and the perception on many issues will tend to be similar.

The female gender indicates greater concern about these issues, in line with previous studies. This is particularly evident for the subject of reducing and banning herbicides of synthetic origin and glyphosate, and the need for the use of alternative methods (Table 13). Women tend to be more concerned about human and environmental health, are more skeptical about pesticide use and prefer the adoption of measures and actions that increase health and safety conditions when using pesticides. (Flynn et al., 1994; McCrigh et al., 2010; Ahmed et al., 2011; Hirsch & Baxter, 2011; Remoundou et al. 2014; Kunin & Lucero, 2020).

People with lower education levels (Up to 9th year) seem to attribute less importance to banning the use of glyphosate in urban areas (Table 13). Education remains central not only in passing on knowledge to younger generations, but also in raising awareness of the implications of the use of chemical compounds, in particular the problem of the release of herbicides into the environment (Coppin et al., 2002; Ahmed et al., 2011).

About the importance given to the increase costs that may relate to the use of alternatives to chemically synthesized herbicides (Tables 13 and 14), opinions are quite divided, with about 40% indicating that it is important to take this into consideration (figure 27). This result is in line with other related literature, in which people are very favorable to more environmentally friendly technologies, but when it comes to increased costs, opinions are less favorable (Qazi et al., 2019). Youngest respondents are the ones who give the most importance to the cost increase.

For the age variable, there is a significant and systematic difference for the under 25 years old group. This group, together with students, do not show the same support for the reduction and prohibition of herbicides, as well as to the use of alternatives, when compared with older people. The attention given to costs is also higher. Despite not assessed in this study, these results may reveal less knowledge or awareness of the younger generations on the subject of herbicides, perceiving them as less dangerous or show more disinterest in the issue. These reasons are in line with other authors, who indicate that although there is a greater concern for the environment, holistic knowledge about environmental protection is lower among the younger population (Hill & Lee, 2012). The techno-optimism of the younger generations may also be relevant to justify these results. Younger techno-optimistic respondents tend to have greater confidence in the use of new technologies, leading them to devalue its environmental and social impacts or to place greater value on the benefits of these technologies, such as lower costs and higher productivity (Peterson, 2000; Dentzman et al., 2016).

4.4. Synthetic chemical herbicides in urban areas - health and environment

Almost 89% of respondents say that they did not believe that herbicides are safe (Figure 28). These results are in line with other related studies, which indicate that there is a great deal of environmental concern regarding the negative impacts of pesticides and other chemical pollutants (Zhang & Fan, 2013; Balzan et al., 2017). However, the male gender and respondents with an academic background in environmental area / ecology show to have much higher confidence in these products than the female gender.

Our results agree with the vast majority of the literature, pointing out that women are more concerned about the environmental and health impacts of pollutants (Flynn et al., 1994; McCrigh et al., 2010; Ahmed et al., 2011; Hirsch & Baxter, 2011; Remoundou et al. 2014; Kunin & Lucero, 2020). Men may be more result-oriented, which in this case means more effective weed control, to the detriment of the health and environmental impacts of the methods used. This focus on results is observed through a sense of taking greater risks, both personal and environmental, to achieve these goals (Cabrera & Leckie, 2009; Hirsch & Baxter, 2011; Ahmed et al., 2011; Remoundou et al. 2014; Yapici et al., 2017; Carmi & Alkaher, 2020; Kunin & Lucero, 2020).

Respondents with an academic background in environmental area / ecology and with university education consider themselves to be informed about the risks of herbicides (Fig. 31 and 32). These groups may understand more of the risks involved in the use of herbicides and probably hold more knowledge about the products as found by Coppin et al. (2002), Yapici et al. (2017) and Carmi & Alkaher (2020).

In general, the recognition of the impacts of herbicides on human and animal health, loss of biodiversity, destruction of natural habitat, air pollution, soil contamination, and contamination of water courses is high across the entire sample (all over 80%) (Fig. 33). The lower perceived impact on air pollution, when compared to the impacts on the other systems, may be due to the understanding that herbicides do not remain suspended in the air for long periods of time, while impacts on soil and water are more often indicated. The high perception found from the respondents that herbicides have impacts on water courses and soils is in line with previous studies that found the same correlation (Yapici et al., 2017; Carmi & Alkaher, 2020).

Respondents from rural areas and women perceived more impacts in the environment, animal and human health (Table 18) caused by herbicides. For the rural area, the factor of having more contact with herbicides may lead them to be more aware of the impacts.

Respondents belonging to the group with academic background in environmental area / ecology perceived slightly less impacts on human and animal health, air and soil. As stated above, this may indicate higher confidence levels in these products and in the methods for its application (Yapici et al., 2017; Carmi & Alkaher, 2020). As for age, the youngest and oldest are who perceive more impacts.

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4.5. Conclusion

Based on the results obtained in this study, citizens' perceptions of the presence of weeds in their areas of residence are high. It also considers that weed control is needed, particularly when they notice their presence.

The majority of the population surveyed in this study do not use herbicides. Those that do use herbicides report opting for synthetic chemical ones. These are respondents who claim to be aware of the control of weeds in their municipality, despite reporting that they do not receive information on control actions. The main channel through which they receive this information is essentially by street warning / notifications in public places. When asked about the methods of control used in their municipality, most of them do not know how the control is carried out. Of those who know, they say that mechanical methods and herbicides with chemical origin are employed. This study shows that there is still a way to go in the communication between local authorities and their residents. Citizens are concerned about this type of actions and want to be informed about what is happening in their area of residence.

Although costs may be higher when searching for and applying alternative methods to synthetic chemical herbicides in weed control, most of the population indicate that it is important to reduce or ban their use, including glyphosate, in urban environments.

About 2/3 of the respondents consider themselves reasonably informed about the risks associated to herbicides and most of them do not perceive them as safe. Accordingly, they perceive the use of herbicides to have negative impacts in the environment and human health. Air pollution was less selected by respondents, as being affected.

Living in a semi-urban or urban area seem to influence citizens' perceptions. They have a greater perception of weeds' presence and considered them to be more informed about weed control actions. People living in rural areas also show higher awareness values about herbicides impacts.

When analyzed by age, the youngest (under 25 years old) are whom stand out from the other age groups. In general, they give more importance to weed control on public roads, know less about what glyphosate is, are less aware of control actions, and are less informed about the control actions in the municipality. The youngest group gives less importance to find more sustainable alternatives to herbicides in urban environments.

Conversely, they are concerned about the use of chemicals and about the impacts in human and animal health.

There is also a significant influence of gender on many of the variables analyzed. Men usually use more chemical origin herbicides, considered to be more informed on the substances used in weed control actions, and show higher levels of confidence in herbicides than women. On the other hand, women want to be more informed about control actions, are more in favor of reducing/banning herbicides (chemical origin), including glyphosate, and support the use of alternatives to chemical control in urban areas. They also perceive as more negative the environmental and human health impacts caused by herbicides.

The level of education (completed) seems to have little influence on citizens' responses. Main exceptions occur when asked about glyphosate, where people with higher level of education are more likely to recognize glyphosate and are more in favor of banning it in urban areas.

The academic background in environment and ecology areas is undoubtedly one of the factors that most influences population's perceptions about herbicides. This group of respondents indicate that there is less need of weed control, show higher values in knowing what glyphosate is, are more aware about the control actions, use more chemical herbicides, perceive them to be safer than the other respondents, consider themselves to be more informed about the risks associated with the use of herbicides and also participate more in activities related to weed control. They also give more importance to the use of alternatives to herbicides. Although the vast majority of this group select that herbicides have negative impacts on the environment, they present lower values when analyzing human and animal health, air pollution and soil contamination.

Few differences are found when analyzed by employment status, with students being the group showing the greatest difference. On the one hand, students are less aware about glyphosate, show higher rates of herbicide use, are more confident in the safety of herbicides, and have lower rates of perceived impacts in biodiversity loss and air pollution than the other groups.

Most of the existing studies focus only on herbicide effects on workers or operators, and there is little literature related with general population. The questions presented in this questionnaire are different from those of the existing studies, making it difficult the comparison with existing literature. With this research, we hope to open a new door to the study of the perceptions of herbicides of the general population and to the control of unwanted plants species in urban environments.

These findings may be useful for decision-making on the management of public areas related to the need to control weeds, as well as for the choice of the best ways of dissemination of control actions performed by the competent authorities. From a legal point of view, this allows us to evaluate the best policies to be taken in order to meet the population's demands when it comes to herbicides with chemical origin, such as their future prohibition in urban areas. However, further studies would be welcomed on the perception of the aesthetic value of weeds, the effects of control on biodiversity or the promotion of biodiversity conservation in urban environments to move forward a more sustainable and environmentally friendly ecosystem.

5. References

Ahmed N., Englund J., Åhman I., Lieberg M. & Johansson E. (2011). Perception of pesticide use by farmers and neighbors in two periurban areas. Science of the Total Environment 412-413, 77–86. Doi: 10.1016/j.scitotenv.2011.10.022.

Anifandis G., Katsanaki K., Lagodonti G., Messini C., Simopoulou M., Dafopoulos K. & Daponte A. (2018). The Effect of Glyphosate on Human Sperm Motility and Sperm DNA Fragmentation. International Journal of Environmental Research and Public Health, 15, 1117. Doi: 10.3390/ijerph15061117.

Archibald C. L., McKinney M., Mustin K., Shanahan D. F. & Hugh P. (2017). Assessing the impact of revegetation and weed control on urban sensitive bird species. Ecology and Evolution, 7, 4200-4208. Doi: 10.1002/ece3.2960.

Aronson M. F. J., La Sorte F. A., Nilon C. H., Katti M., Goddard M. A., Lepczyk C. A., Warren P. S., Williams N. S. G., Cilliers S., Clarkson B., Dobbs C., Dolan R., Hedblom M., Klotz S., Kooijmans J. L., Kühn I., MacGregor-Fors I., McDonnell M., Mörtberg U., Pyšek P., Siebert S., Sushinsky J., Werner P. & Winter M. (2014). A global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers. Proceedings of the Royal Society B: Biological Sciences, 281. Doi: 10.1098/rspb.2013.3330.

Aronson M. F. J., Piana M. R., MacIvor J. S. & Pregitzer C. C. (2017). Management of plant diversity in urban green spaces. In: Ossola A. & Niemelä J. (eds.). Urban Biodiversity. Routledge, London, 101-120. Doi: 10.9774/gleaf.9781315402581_8.

Avila-Vazquez M., Difilippo F.S., Lean B.M., Maturano E. & Etchegoyen, A. (2018). Environmental Exposure to Glyphosate and Reproductive Health Impacts in Agricultural Population of Argentina. Journal of Environmental Protection, 9, 241-253. Doi: 10.4236/jep.2018.93016.

Balzan S., Fasolato L., Cardazzo B., Penon C. & Novelli E. (2017). Genuine and natural: the opinion of teen consumers. Italian Journal of Food Safety, 6. Doi:10.4081/ijfs.2017.6183.

Baker H. B. (1974). The evolution of weeds. Annual Review of Ecology and Systematics, 5, 1-24.

Barrico L. & Castro P. (2016). Urban Biodiversity and Cities' Sustainable Development. In P. Castro et al. (eds.), Biodiversity and Education for Sustainable Development, World Sustainability Series. Doi: 10.1007/978-3-319-32318-3_3.

Benbrook C. (2016). Trends in glyphosate herbicide use in the United States and globally. Environmental Sciences Europe, 28, 3 Doi: 10.1186/s12302-016-0070-0.

Benvenuti S. (2004). Weed dynamics in the Mediterranean urban ecosystem: ecology, biodiversity and management. Weed Research 44, 341–354. Doi: 10.1111/j.1365-3180.2004.00410.x.

Britannica, T. Editors of Encyclopaedia (2020). Weed. Encyclopedia Britannica. https://www.britannica.com/plant/weed.

Cabrera N.L. & Leckie J.O. (2009). Pesticide risk communication, risk perception, and self-protective behaviors among farm workers in California's Salinas Valley. Hispanic Journal of Behavioral Sciences, 31, 258-272. Doi: 10.1177/0739986309331877.

Carmi N. & Alkaher I. (2019). Risk Literacy and Environmental Education: Does Exposure to Academic Environmental Education Make a Diference in How Students Perceive Ecological Risks and Evaluate Their Risk Severity? Sustainability, 11, Doi: 10.3390/su11226350.

Censos 2011 - Resultados Definitivos – Portugal. (2011). Instituto Nacional de Estatística, I.P. Lisboa. ISBN: 978-989-25-0181-9.

Cicognani E.,Zani B., Fournier B., Gavray C. & Born M. (2012). Gender differences in youths' political engagement and participation. The role of parents and of adolescents' social and civic participation. Journal of Adolescence, 35, 561–576. Doi: 10.1016/j.adolescence.2011.10.002

Chopra A. K., Sharma M. K. & Chamoli S. (2011). Bioaccumulation of organochlorine pesticides in aquatic system—an overview. Environ Monit Assess, 173, 905–916. Doi: 10.1007/s10661-010-1433-4.

Collotta M., Bertazzi P.A. & Bollati V. (2013). Epigenetics and pesticides. Toxicology, 307, 35–41. Doi: 10.1016/j.tox.2013.01.017.

Coppin, D., Eisenhauer, B., & Krannich, R. (2002). Is Pesticide Use Socially Acceptable? A Comparison between Urban and Rural Settings. Social Science Quarterly, 83, 379-394.

Corsini E., Sokooti M., Galli C.L., Moretto A. & Colosio C. (2013). Pesticide induced immunotoxicity in humans: A comprehensive review of the existing evidence. Toxicology, 307, 123– 135. Doi: 10.1016/j.tox.2012.10.009.

Dardiotis E., Xiromerisiou G., Hadjichristodoulou C., Tsatsakis A. M., Wilks M. F. & Hadjigeorgiou G. M. (2013). The interplay between environmental and genetic factors in Parkinson's disease susceptibility: The evidence for pesticides. Toxicology, 307, 17– 23. Doi: 10.1016/j.tox.2012.12.016.

Dawson V. (2007). An Exploration of High School (12–17 Year Old) Students' Understandings of, and Attitudes Towards Biotechnology Processes. Research in Science Education, 37, 59–73. Doi: 10.1007/s11165-006-9016-7.

Decree-law n.º 35/2017 de 24 de março. Altera a regulação dos produtos fitofarmacêuticos, transpondo a Diretiva n.º 2009/128/CE. Diário da República n.º 60/2017, Série I de 2017-03-24, 1616 – 1617.

DEFRA. (2015). Best Practice Guidance. Notes for Integrated and Non-chemical Amenity Hard Surface Weed Control. Development of zero and minimal herbicide regimes for controlling weeds on hard surfaces and determining their emissions PS2802 (2009-2015).

Dentzman K, Gunderson R & Jussaume R. (2016). Techno-optimism as a barrier to overcoming herbicide resistance: Comparing farmer perceptions of the future potential of herbicides. Journal of Rural Studies, 48, 22–32. Doi: 10.1016/j.jrurstud.2016.09.006.

DGT (2014). LANDYN - Alterações de uso e ocupação do solo em Portugal Continental: caracterização, forças motrizes e cenários futuros. Relatório de execução da Tarefa 3, identificação das principais forças motrizes: abordagem quantitativa. Direção-Geral do Território (DGT), Lisboa.

DGT (2016). Habitat III - Relatório Nacional. Lisboa. ISBN: 978-989-8785-07-7.

Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides (Text with EEA relevance). Official Journal of the European Communities, 309, 24.11.2009, 71–86.

Dijkstra L., Florczyk A. J., Freire S., Kemper T., Melchiorri M., Pesaresi M. & Schiavina M. (2020). Applying the Degree of Urbanisation to the globe: A new harmonised definition reveals a different picture of global urbanization. Journal of Urban Economics. Doi: 10.1016/j.jue.2020.103312.

Douglas, I., & James, P. (2015a). Urban Ecology: An Introduction. Routledge. ISBN: 978–0-203–10870–3.

European Weed Research Society (1986). Constitution. 15.

Eurostat (2017). Retrieved from: https://ec.europa.eu/eurostat/data/database.

FAO (2020). Pesticides Use Statistics. Global, regional and country trends 1990–2018. FAOSTAT Analytical Brief Serie, Rome, FAO. Available at: http://www.fao.org/3/cb0488en/CB0488EN.pdf.

FAO and WHO. 2020. Pesticide residues in food 2019 - Report 2019 - Joint FAO/WHO Meeting on Pesticide Residues. Rome. ISBN: 978-92-5-132086-0.

Flynn J., Slovic P. & Mertz C.K. (1994). Gender, Race, and Perception of Environmental Health Risks. Risk Analysis, XIV, 1101–1108.

Francis R. A., Millington J. D. A. & Chadwick M. A. (2016). An overview of landscape ecology in cities. In: Francis R. A., Millington J. D. A. & Chadwick M. A. (eds). Urban Landscape Ecology: Science, policy and practice. Routledge, London, 1-18. ISBN: 9781315713373.

Gillezeau C., van Gerwen M., Shaffer R. M., Rana I., Zhang L., Sheppard L. & Taioli E. (2019). The evidence of human exposure to glyphosate: a review. Environmental Health, 18. Doi: 10.1186/s12940-018-0435-5.

Hernández, A. F., Parrón, T., Tsatsakis, A. M., Requena, M., Alarcón, R., & López-Guarnido, O. (2013). Toxic effects of pesticide mixtures at a molecular level: Their relevance to human health. Toxicology, 307, 136–145. Doi: 10.1016/j.tox.2012.06.009.

Hill J. & Lee, H. (2012). Young Generation Y consumers' perceptions of sustainability in the apparel industry. Journal of Fashion Marketing and Management, 16, 477-491. Doi: 10.1108/13612021211265863.Hirsch R.A. & Baxter J. (2011). Context, cultural bias, and health risk perception: The "everyday" nature of pesticide policy preferences in London, Calgary, and Halifax. Risk Analysis, 2011; 31, 847– 865. Doi: 10.1111/j.1539-6924.2010.01560.x.

Hirsch, R. A., & Baxter, J. (2011). Context, Cultural Bias, and Health Risk Perception: The "Everyday" Nature of Pesticide Policy Preferences in London, Calgary, and Halifax. Risk Analysis, 31(5), 847–865. Doi: 10.1111/j.1539-6924.2010.01560.x.

Hosseini Bai S. & Ogbourne S. M. (2016). Glyphosate: environmental contamination, toxicity and potential risks to human health via food contamination. Environmental Science Pollution Research, 23, 18988–19001. Doi: 10.1007/s11356-016-7425-3.

Huddart-Kennedy E., Beckley T. M., McFarlane B. L., & Nadeau S. (2009). Rural–urban differences in environmental concern in Canada. Rural Sociology, 74, 309–329. Doi: 10.1526/003601109789037268.

Humburg N.E,, Colby S. R., Lym R.G., Hill E. R., McAvoy W.J., Kitchen L. M., Prasad R., Eds. Herbicide handbook of the Weed Science Society of America. Weed Science Society of America: Champaign, IL, 1989. ISBN 10: 0911733132.

IARC (2015). IARC Monographs Volume 112: evaluation of five organophosphate insecticides and herbicides. WHO. Retrieved from: https://www.iarc.who.int/wp-content/uploads/2018/07/MonographVolume112-1.pdf.

INE - Instituto Nacional de Estatística, I.P. (2019). Retrieved from: https://www.ine.pt/xportal/xmain?xpgid=ine_main&xpid=INE&xlang=pt.

Jurado A. S., Fernandes M. A. S., Videira R. A., Peixoto F. P. & Vicente J. A. F. (2011). Herbicides: The Face and the Reverse of the Coin. An in vitro Approach to the Toxicity of Herbicides in Non-Target Organisms. In: Kortekamp A. (ed.). Herbicides and environment, InTech, Rijeka, 3-44. ISBN 978-953-307-476-4.

Jarman W. J. & , Ballschmiter K. (2012). From coal to DDT: the history of the development of the pesticide DDT from synthetic dyes till Silent Spring. Endeavour, 36. Doi: 10.1016/j.endeavour.2012.10.003.

Kanavouras K., Tzatzarakis M. N., Mastorodemos V., Plaitakis A. & Tsatsakis A. M. (2011). A case report of motor neuron disease in a patient showing significant level of DDTs, HCHs and organophosphate metabolites in hair as well as levels of hexane and toluene in blood. Toxicology and Applied Pharmacology, 256, 399–404. Doi: 10.1016/j.taap.2011.07.022.

Kim K., Kabir E. & Jahan S. (2017). Exposure to pesticides and the associated human health effects. Science of the Total Environment, 575, 525–535. Doi: 10.1016/j.scitotenv.2016.09.009.

Kleijn D. & Sutherland W. J. (2003). How effective are European agri-environment schemes in conserving and promoting biodiversity? Journal of Applied Ecology, 40, 947–969. Doi: 10.1111/j.1365-2664.2003.00868.x.

Koutros S., Silverman D., Alavanja M., Andreotti G., Lerro C., Heltshe S., Lynch C.F., Sandler D.P., Blair A. & Beane Freeman L.E. (2016). Occupational exposure to pesticides and bladder cancer risk. International journal of epidemiology, 45, 792-805. Doi:10.1093/ije/dyv195.

Kristoffersen P., Rask A. M., Grundy A.C., Franzen I., Kempena A. R. C., Raisio J., Schroeder H., Spijker J., Verschwele A. & Zarina L. (2008). A review of pesticide policies and regulations for urban amenity areas in seven European countries. Weed Research, 48, 201–214.

Kristoffersen P., Rask A. M. & Larsen S. U. (2008). Non-chemical weed control on traffic islands: a comparison of the efficacy of five weed control techniques. Weed Research, 48, 124–130. Doi: 10.1111/j.1365-3180.2007.00612.x.

Kumar, R. (2011). Research Methodology: A Step-by-Step Guide for Beginners (Third ed.). SAGE Publications Ltd.

Kunin, J., & Lucero, P. (2020). Percepción social del riesgo y dinámicas de género en la producción agrícola basada en plaguicidas en la pampa húmeda Argentina. Sexualidad, Salud y Sociedad-Revista Latinoamericana, 58-81. Doi: 10.1590/1984-6487.sess.2020.35.04.a.

Lambert M. R. & Donihue C. M. (2020). Urban biodiversity management using evolutionary tools. Nature Ecology & Evolution, 4, 903–910. Doi: 10.1038/s41559-020-1193-7.

Law No. 26/2013, of April 11. Regula as atividades de distribuição, venda e aplicação de produtos fitofarmacêuticos para uso profissional e de adjuvantes de produtos fitofarmacêuticos e define os procedimentos de monitorização à utilização dos produtos fitofarmacêuticos. Diário da República n.º 71/2013, Série I de 2013-04-11, 2100 – 2125.

Lee C., Kim T. & Mjelde J. W. (2014) Comparison of preservation values between Internet and interview survey modes: the case of Dokdo, South Korea. Journal of Environmental Planning and Management, 59, 22-43, Doi: 10.1080/09640568.2014.980900.

Lefrancq, M., Jadas-Hécart, A., La Jeunesse, I., Landry, D., & Payraudeau, S. (2017). High frequency monitoring of pesticides in runoff water to improve understanding of their transport and environmental impacts. Science of The Total Environment, 587–588, 75–86. Doi: 10.1016/j.scitotenv.2017.02.022.

McCance W., Jones O.A.H., Edwards M., Surapaneni A., Chadalavada S. & Currell M. (2018). Contaminants of Emerging Concern as novel groundwater tracers for delineating wastewater impacts in urban and peri-urban areas. Water Research, 146, 118-133. Doi: 10.1016/j.watres.2018.09.013.

McDonald R. I., Marcotullio P. J. & Güneralp B. (2013). Urbanization and Global Trends in Biodiversity and Ecosystem Services. In T. Elmqvist et al. (eds.), Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment. Doi: 10.1007/978-94-007-7088-1_3.

McDonald R.I, Mansur A:V., Ascensão F., Colbert M., Crossman K., Elmqvist T., Gonzalez A., Güneralp B., Haase D., Hamann M., Hillel O., Huang K., Kahnt B., Maddox D., Pacheco A., Pereira H. M., Seto K. C., Simkin r., Walsh B., Werner A. S. & Ziter C. (2019). Research gaps in knowledge of the impact of urban growth on biodiversity. Nature Sustainability, 3, 16–24. Doi: 10.1038/s41893-019-0436-6.

MacLeod A., Pautasso M., Jeger M. J. & Haines-Young R. (2010). Evolution of the international regulation of plant pests and challenges for future plant health. Food Security, 2, 49–70. Doi: 10.1007/s12571-010-0054-7.

Mackay D. & Fraser A. (2000). Bioaccumulation of persistent organic chemicals: mechanisms and models. Environmental Pollution, 110, 375-391. Doi: 10.1016/S0269-7491(00)00162-7.

Marshall J., Brown V., Boatman N., Lutman P. & Squire G. 2001. The impact of herbicides on weed abundance and biodiversity PN0940. A report for the UK Pesticides Safety Directorate, IACR-Long Ashton Research Station.

McCright & Aaron M. (2010). The Effects of Gender on Climate Change Knowledge and Concern in the American Public. Population and Environment 32, 66–87. Doi: 10.1007/s11111-010-0113-1.

Medehouenou T. C. M., Ayotte P., Carmichael P., Kröger E., Verreault R., Lindsay J., Dewailly E., Tyas S. L., Bureau A. & Laurin D. (2014). Plasma polychlorinated biphenyl and organochlorine pesticide concentrations in dementia: The Canadian Study of Health and Aging. Environment International, 69, 141-147. Doi: 10.1016/j.envint.2014.04.016.

Mesnage R. & Antoniou M. N. (2018). Ignoring Adjuvant Toxicity Falsifies the Safety Profile of Commercial Pesticides. Frontiers in Public Health 5, 361. Doi: 10.3389/fpubh.2017.00361.

Mesnage R., Benbrook C. & Antoniou M. N. (2019). Insight into the confusion over surfactant co-formulants in glyphosate-based herbicides. Food and Chemical Toxicology, 128, 137–145. Doi: 10.1016/j.fct.2019.03.053.

Mobley, C., Vagias, W. M., & DeWard, S. L. (2010). Exploring additional determinants of environmentally responsible behavior: The influence of environmental literature and environmental attitudes. Environment and Behavior, 42, 420–447. Doi: 10.1177/0013916508325002.

Moon J. M., B. J. Chun, Cho Y. S., Lee S. D., Hong Y. J., Shin M. H., Jung E. J. & Ryu H. H. (2018). Cardiovascular Effects and Fatality May Differ According to the Formulation of Glyphosate Salt Herbicide. Cardiovascular Toxicology, 18, 99–107. Doi: 10.1007/s12012-017-9418-y.

Moretto A. & Colosio C. (2013). The role of pesticide exposure in the genesis of Parkinson's disease: Epidemiological studies and experimental data. Toxicology, 307, 24– 34. Doi: 10.1016/j.tox.2012.11.021.

Mostafalou S & Abdollahi M. (2013). Pesticides and human chronic diseases: Evidences, mechanisms, and perspectives. Toxicology and Applied Pharmacology, 268, 157–177. Doi: 10.1016/j.taap.2013.01.025.

Mostafalou S & Abdollahi M. (2017). Pesticides: an update of human exposure and toxicity. Archives of Toxicology, 91, 549–599. Doi: 10.1007/s00204-016-1849-x.

Mullin C. A:, Frazier M., Frazier J. L., Ashcraft S., Simonds R., van Engelsdorp D. & Pettis J. S. (2010). High Levels of Miticides and Agrochemicals in North American Apiaries: Implications for Honey Bee Health. PLoS ONE 5. Doi: 10.1371/journal.pone.0009754.

Myers J. P., Antoniou M. N., Blumberg B., Carroll L., Colborn T., Everett L. G., Hansen M., Landrigan P. J., Lanphear B. P., Mesnage R., Vandenberg L. N., vom Saal F. S., Welshons W. V. & Benbrook C. M. (2016). Concerns over use of glyphosate-based herbicides and risks associated with exposures: a consensus statement. Environmental Health, 15, 19. Doi: 10.1186/s12940-016-0117-0.

Nabais C., Barrico M.L., Freitas H. & Prasad M.N.V. (2007). Agriculture-induced contamination of surface water and groundwater in Portugal. Developments in Environmental Science, 5, 197-208. Doi: 10.1016/S1474-8177(07)05009-7.

Nicolopoulou-Stamati P., Maipas S., Kotampasi C., Stamatis P. & Hens L. (2016). Chemical Pesticides and Human Health: The Urgent Need for a New Concept in Agriculture. Frontiers in public health, 4, 148. Doi: 10.3389/fpubh.2016.00148.

Niemann L., Sieke C., Pfeil R. & Solecki R. (2015). A critical review of glyphosate findings in human urine samples and comparison with the exposure of operators and consumers. Journal of Consumer Protection and Food Safety, 10, 3–12. Doi: 10.1007/s00003-014-0927-3.

Ordinance No. 82/2019 de 20 de março. Aprova o Plano de Ação Nacional para o Uso Sustentável dos Produtos Fitofarmacêuticos - 1.ª Revisão. Diário da República n.º 56/2019, Série I de 2019-03-20, 1678 – 1679.

Ostiguy N., Drummond F. A., Aronstein K., Eitzer B., Ellis J. D., Spivak M. & Sheppard W. S. (2019). Honey Bee Exposure to Pesticides: A Four-Year Nationwide Study. Insects, 10, 13. Doi: 10.3390/insects10010013.

Parrón T., Requena M., Hernández A. F. & Alarcón R. (2014). Environmental exposure to pesticides and cancer risk in multiple human organ systems. Toxicology Letters, 230, 157–165. Doi: 10.1016/j.toxlet.2013.11.009.

Peterson R. K. D. (2000). Public perceptions of agricultural biotechnology and pesticides: recent understandings and implications for risk communication. American Entomologist, 46, 8-16.

Qazi A., Hussain F., Abd. Rahim N., Hardaker G., Alghazzawi D., Shaban K., & Haruna K. (2019). Towards Sustainable Energy: A Systematic Review of Renewable Energy Sources, Technologies, and Public Opinions. IEEE acess. Doi: 10.1109/ACCESS.2019.2906402.

Rask A. M. & Kristoffersen P. (2007). A review of non-chemical weed control on hard surfaces. Weed Research, 47, 370–380. Doi: 10.1111/j.1365-3180.2007.00579.x.

Rask A. M., Larsen S. U., Andreasen C. & Kristoffersen P. (2013). Determining treatment frequency for controlling weeds on traffic islands using chemical and non-chemical weed control. Weed Research, 53, 249–258. Doi: 10.1111/wre.12019.

Regulation (EC) No 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC. Official Journal of the European Communities, 309, 24.11.2009, 1–50.

Remoundou K., Brennan M., Hart A. & Frewer L. J. (2014). Pesticide Risk Perceptions, Knowledge, and Attitudes of Operators, Workers, and Residents: A Review of the Literature. Human and Ecological Risk Assessment, 20, 1113-1138. Doi: 10.1080/10807039.2013.799405.

RTP 2013 - Retrato Territorial de Portugal 2013. (2015). Instituto Nacional de Estatística, I.P. ISBN: 978-989-25-0315-8.

Ríos-González A., Jansen K. & Sánchez-Pérez H. J. (2013). Pesticide risk perceptions and the differences between farmers and extensionists: Towards a knowledge-in-context model. Environmental Research, 124, 43–53. Doi: 10.1016/j.envres.2013.03.006.

Rupprecht C. C. D. (2017). Informal Urban Green Space: Residents' Perception, Use, and Management Preferences across Four Major Japanese Shrinking Cities. Land, 6, 59. Doi: 10.3390/land6030059.

Sahin H. (2019). A Review on Parameters Affecting the Choice of Alternative (Non Chemical) Weed Control Methods. European Journal of Engineering Research and Science Vol. 4, 12. Doi: 10.24018/ejers.2019.4.12.1641.

Salomons W. (1994). Environmental impact of metals derived from mining activities: Processes, predictions, prevention. Journal of Geochemical Exploration, 52, 5-23. Doi: 10.1016/0375-6742(94)00039-E.

Sanin L., Carrasquilla G., Solomon K. R., Cole D. C. & Marshall E. J. P. (2009). Regional Differences in Time to Pregnancy Among Fertile Women from Five Colombian Regions with Different use of Glyphosate. Journal of Toxicology and Environmental Health, Part A, 72, 15-16, 949-960. Doi: 10.1080/15287390902929691.

Sasal M.C., Wilson M.G., Sione S.M., Beghetto S.M., Gabioud E.A, Oszust J.D., Paravani E.V., Demonte L., Repetti M.R., Bedendo D.J., Medero S.L., Goette J.J., Pautasso N. & Schulz G.A. (2017) Monitoring of glyphosate in surface water in the province of Entre Ríos. Participatory action research as a collaborative methodology. Revista de Investigaciones Agropecuarias, 43, 4-13.

Schwarzenbach R. P., Egli T., Hofstetter T. B., von Gunten U. & Wehrli B. 2010. Global Water Pollution and Human Health. Annual Review of Environment and Resources, 35, 109–36. Doi: 10.1146/annurev-environ-100809-125342.

Skark C., Zullei-Seibert N., Willme U., Gatzemann U. & Schlett C. (2004). Contribution of non-agricultural pesticides to pesticide load in surface water. Pest Management Science, 60, 525–530. Doi: 10.1002/ps.844.

Steffen W., Richardson K., Rockstrom J., Cornell S. E., Fetzer I., Bennett E. M., Biggs R., Carpenter S. R., de Vries W., de Wit C. A., Folke C., Gerten D., Heinke J., Mace G. M., Persson L. M., Ramanathan V., Reyers B. & Sorlin S. (2015). Planetary boundaries: Guiding human development on a changing planet. Science, 347. Doi: 10.1126/science.1259855Science.

Stockemer, D. (2019). Quantitative Methods for the Social Sciences. Springer Publishing. ISBN: 978-3-319-99117-7.

Stuart M., Lapworth D., Crane E. & Hart A. (2012). Review of risk from potential emerging contaminants in UK groundwater. Science of the Total Environment, 416, 1–21. Doi:10.1016/j.scitotenv.2011.11.072.

Tanner C. M., Kamel F., Ross G. W., Hoppin J. A., Goldman S. M., Korell M., Marras C., Bhudhikanok G. S:, Kasten M., Chade A. R., Comyns K., Richards M. B., Meng C., Priestley B., Fernandez H. H., Cambi F., Umbach D. M., Blair A., Sandler D. P. & Langston J. W. (2011). Rotenone, Paraquat, and Parkinson’s Disease. Environmental Health Perspectives, 119, 6. Doi: 10.1289/ehp.1002839.

Tarazona J. V., Court-Marques D., Tiramani M., Reich H., Pfeil R., Istace F., Crivellente F. (2017). Glyphosate toxicity and carcinogenicity: a review of the scientific basis of the European Union assessment and its differences with IARC. Archives of Toxicology, 91, 2723–2743. Doi: 10.1007/s00204-017-1962-5.

TIPAU - Tipologia de áreas urbanas. (2014). INE. Retrieved from: http://smi.ine.pt/Versao/Download/10129.

United Nations, Department of Economic and Social Affairs, Population Division. (2018). The World’s Cities in 2018—Data Booklet (ST/ESA/ SER.A/417).

United Nations. (2020). Human Development Report 2020: The next frontier: Human development and the Anthropocene. ISBN: 978-92-1-126442-5.

Van Bruggen, A. H. C., He, M. M., Shin, K., Mai, V., Jeong, K. C., Finckh, M. R. & Morris, J. G. Jr. (2018). Environmental and health effects of the herbicide glyphosate. Science of the Total Environment, 616–617, 255–268. Doi: 10.1016/j.scitotenv.2017.10.309.

Van Stempvoort D. R., Spoelstra J., Senger N. D., Brown S. J., Post R. & Struger J. (2016). Glyphosate residues in rural groundwater, Nottawasaga RiverWatershed, Ontario, Canada. Pest Management Science, 72, 1862–1872. Doi: 10.1002/ps.4218.

Vazquez M. A., Maturano E., Etchegoyen A., Difilippo F. S. & Maclean B. (2017). Association between Cancer and Environmental Exposure to Glyphosate. International Journal of Clinical Medicine, 8, 73-85. Doi: 10.4236/ijcm.2017.82007.

Voicu M. & Voicu B. (2016). Civic Participation and Gender Beliefs: An Analysis of 46 Countries. Czech Sociological Review, 52, 321–345. Doi: 10.13060/00380288.2016.52.3.261.

Weber F., Kowarik I. & Säumel I. (2014). A walk on the wild side: perceptions of roadside vegetation beyond trees. Urban Forestry& Urban Greening, 13, 205-212. Doi: 10.1016/j.ufug.2013.10.010.

WHO. (2018). WHO Chemical Safety - Activity Report 2018. Geneva: World Health Organization; 2018. (WHO/CED/PHE/EPE/19.8).

WHO. (2019). Preventing disease through healthy environments - Exposure to highly hazardous pesticides: a major public health concern. Geneva: World Health Organization; 2019. (WHO/CED/PHE/EPE/19.4.6).

Yapici G., Ögenler O., Öner Kurt A., Koças F. & Sasmaz T. (2017). Assessment of environmental attitudes and risk perceptions among university students in Mersin, Turkey. Journal of Environmental and Public Health. Doi: 10.1155/2017/5650926.

Zaganas I., Kapetanaki S., Mastorodemos V., Kanavouras K., Colosio C., Wilks M. F. & Tsatsakis A. M. (2013). Linking pesticide exposure and dementia: What is the evidence? Toxicology, 307, 3– 11. Doi: 10.1016/j.tox.2013.02.002.

Zimdahl R. L. (2007). Fundamentals of weed science. Academic Press. ISBN 978-0-12-372518-9.

Zimdahl R. L. (2007). Introduction. In: Smith (ed.). Handbook of weed management systems. Taylor & Francis, New York, 1-18. ISBN 0-8247-9547-4.

Zhang C. & Fan J. (2013). A Study of the Perception of Health Risks among College Students in China. International Journal of Environmental Research and Public Health, 10, 2133-2149. Doi: 10.3390/ijerph10062133.

Zhang W. J., Jiang F.B. & Ou J. F. (2011). Global pesticide consumption and pollution: with China as a focus. Proceedings of the International Academy of Ecology and Environmental Sciences, 2011, 1, 125-144.