International Journal for Environmental Rehabilitation and Conservation

essence

ISSN: 0975 — 6272
XI (SP2): 384 — 399
www.essence-journal.com

Original Research Article

Circumstances of development of Butachlor generation industries in the field of agricultural applications

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A R T I C L E I N F O

Received: 21 July 2020 | Accepted: 15 August 2020 | Published Online: 30 September 2020

EOI: 10.11208/essence.20.11.SP2.165

A B S T R A C T

The butachlor as an herbicide has been widely used in agricultural applications in Iran. The toxicity of butachlor reported in a variety of studies. This review collected recent studies for the circumstances of the development of butachlor generation industries in the field of agricultural applications despite the mentioned drawbacks. It was used the valuable references and resources in writing the current review. The findings recommended to use of plasma technology in the green butachlor generation and retrieve the butachlor wastes that are emerged in the manufacturing technologies. It was concluded that the efficiency and performance of butachlor is a prominent point in agricultural usages and other alternatives introduced to be replaced with butachlor must provide the efficiency expected.

K E Y W O R D S

Industry Development | Butachlor | Agricultural Applications

C I T A T I O N

Malek Hassanpour (2020): Circumstances of development of Butachlor generation industries in the field of agricultural applications (A review). ESSENCE Int. J. Env. Rehab. Conserv. XI (SP2): 384 — 399. https://eoi.citefactor.org/10.11208/essence.20.11.SP2.165

Introduction

Despite the existence of various pest control methods such as biological, agricultural, physical control methods, *etc*. unfortunately, in most countries of the world, the use of chemical herbicides is still the dominant method in pest control and it is predicted that this method will be used in the future. To be used to control pests and increase agricultural production. The pesticide used is expected to have the least adverse health and environmental impact while being effective. Therefore, in the current situation, the most important option before use is the management of herbicide consumption in the country (Remucal 2014). In Iran, like many countries in the world, the use of herbicide is one of the main methods of weeds control. But despite the benefits associated with the use of this compound in increasing plant production, its indiscriminate and uninformed use can be the source of many health and environmental problems. Herbicides are considered among agricultural sources as one of the known or suspected causes of cancer or hormonal disorders in humans, so in risk assessment programs, carcinogens have been considered as an important factor (Ramah 2011). The use of synthetic chemicals as herbicide began in the 1930s and became more widespread during the 1940s and after World War II. Statistics show that the highest amount of herbicides is consumed by farmers in agricultural lands in the northern provinces of the country (Tavakol 2007).

The butachlor firstly introduced in Japan in 1973 and then India (Tilak *et al.,* 2007). Butachlor (N-(butoxymethyl)-2-chloro-N-(2, 6-diethylphenyl) acetamide), which is used as an herbicide, increases the yield of rice and corn. It has been used as an herbicide against weeds such as Echinochloa colonum, Echinochloa crus-galli, Cyperus difformis, Cyperus iria, Eclipta alba, Fimbristylis miliacea, Ludwigia parviflora, Sphenoclea zeylanica Monochoria vaginalis with a dose/ha around 1.25-1.5 kg, for the butachlor 50% (Choudhury *et al.,* 2016). This pesticide is one of the three most widely used herbicides in China and the Philippines. It is also a selected toxin for weed control in Iranian paddy fields, which decomposes at 165°C but is stable in the exposure of ultraviolet (UV) light. It dissipates dangerous fumes of HCL and NOX in breakdown temperature. Butachlor dissipated into the atmosphere via vapor and particulate phases at low pressure and 25°C. It has known as a persistent compound to UV light with Henry's law constant around 5.10 × 10-8 atm-cu m/mol at 25°C. With the short half-life, the interaction in the atmosphere dissociates the butachlor and produces hydroxyl radicals in the photochemical phenomena. The low soil adsorption coefficient of butachlor (around 700) impede penetration of compound in the soil layers very intangible. Therefore, it is not able to pass through the soil and pollute the underground waters. But it has high hydrophobic characteristics. On the other hand, the valorization of butachlor in water-saturated farms is impossible with regard to Henry's law constant. It will be interrupted in the sediments and captured into suspended solids so will be remediated from the environment (Abigail *et al.,* 2015). The main roles display by both processes of wet and dry depositions from the atmosphere sweeping when the compound emerges in particulate form in the outdoor air (Abigail *et al.,* 2015).

The butachlor is employed to remove the macrophytes that emerged in freshwater fish ponds in the submerged injection. Also, it has adverse effects on the growth, breath, and regeneration of earthworms' viz. Eisenia fetida and Perionyx sansibaricus nitrogen fixation bacteria and photosynthesis of many cyanobacterial species viz. Anabaena doliolum and Nostoc. It has been recognized as a potential carcinogen in animals and humans (Abigail *et al.,* 2015). Butachlor consumption rate has been reported around 4.5 × 107 kg per year in Asia alone in 2015 (Abigail *et al.,* 2015). The stability of Butachlor in aquatic and terrestrial ambient reported being a half-life of 1.65-5.33 days (Huarong *et al.,* 2010). Butachlor is thought to contain carcinogenic and mutagenic characteristics. The report of Dwivedi *et al.,* (2012) noticed to evidence of generating intracellular reactive oxygen Species and serious damages to DNA by butachlor exposures for the first time. Butachlor is absorbed by the skin and is converted to 4-hydroxybutyachlor. This herbicide has been identified in groundwater, wells near farms in the Philippines, and also water in Anzali wetland (Kaur *et al.,* 2017). The recent studies reported to the annual consumption of six thousand tons of synthetic herbicides, organ phosphorus compounds, dinitroaniline's, acetanilides, etc in Iran (Morteza *et al.,* 2017). Today, herbicides are mainly used in agriculture to control plant pests, but the excessive and continuous use of pesticides endangers human health and has adverse effects on non-target organisms and causes pollution of water, soil, and air resources.

Toxicology is the study of the adverse effects of chemical or physical substances on organisms. Adverse effects can occur in many forms, from immediate death to small changes that can be detected months or years later. It has been found that many different observable changes in the structure or activities of the body are the result of previously unrecognizable changes in the body. In general, the toxicity of a contaminant is assessed by a bioassay test, which determines the concentration required to cause the loss of half of the organisms tested in a given period of time (short and long term). These tests are a branch of ecotoxicology. Its role is to judge the potential of pollutants and to investigate the harmful effects of these substances on ecosystems and living organisms. The effect of butachlor herbicide on some hematological parameters in whitefish has been investigated and in it the, major hematological response of whitefish to butachlor toxin has been significantly reduced by red blood cells, hemoglobin, and hematocrit (Jenkins *et al.,* 2003; Hedayati *et al.,* 2017; Xiang *et al.,* 2018; Muthukaruppan *et al.,* 2005). The butachlor has been known as a genotoxic and carcinogen compound on rats in lab exposures (Yakovleva *et al.,* 2003). The studies reported to the emergence of stomach tumors in rats (Li *et al.,* 2019; Li *et al.,* 2016; Zhu *et al.,* 2014). The research by Vajargah *et al.,* (2017) declared that LC50 96 h butachlor for R. rutilus caspicus and S. lucioperca reported to around 0.342 and 0.760 ppm respectively. Trichoderma viride and Pseudomonas alcaligenes were reported to rapidly dissociate Butachlor up to 98 – 75 % during a period of 15 and 21 days, respectively. The Butachlor residue analysis proved the Trichoderma genus as an excellent Butachlor degrader which could be due to the presence of enzymes (cellulases and chitinases), available in its mycelium (Habiba 2012). These findings proved that butachlor is able to alter the mRNA layout of genes and led to rising whole-body thyroid hormone levels of X. laevis tadpoles and conduct damage to thyroid endocrine disruption and extension in toxicity of exposed groups (Li *et al.,* 2016). Butachlor is a lipophilic, a stable toxin in the atmosphere, and potentially attractive compound to bioaccumulation in aquatic creators and organisms with a rising trend of concerns in this field. The intensive toxicity of Butachlor has been observed on green algae, fish, and microorganisms of soil, enzymes, and earthworms (Bian *et al.,* 2009). Butachlor is known as an herbicide listed in the persistent organic pollutants in the atmosphere and able to dissolve in fat with high attraction in biomagnification and bioaccumulation characteristics (Ahmadivand *et al.,* 2014).

There are different organizations that participate in setting many regulations for the allowable concentrations of toxins, elements, herbicides, and pesticides, etc in potable water and surface water samples and drinking water samples such as Environment Protection Agency, World Health Organization and etc. The EU regulation enacted for the allowable concentration of single butachlor in drinking water is around 0.1 ng/ml (Dzantiev *et al.,* 2005). Butachlor has been posed as a damaging compound to the agro-ecosystem and to human life via food chain exposures because it is a relatively stable toxin in soil. So, the allowable concentration of butachlor should not appear upper than 0.1 ng/mL according to the recommendation of EU regulations (Abigail *et al.,* 2015). The LD50 is estimated around at 3300 mg/kg according to WHO recommended classification of pesticides by hazards (WHO 2020).

Physico-chemical properties of butachlor are the chemical name of butachlor N-(butoxymethyl)-2-chloro-N-2,6-dimethyl acetanilide, Molecular formula ($C_{17}H_{26}NO_2Cl$), CAS NO (23184-66-9), molecular weight (311.9), physical state (clear amber liquid at room temperature), odor (faint, sweet odor), density (1.070 g/ml at 25℃, boiling point (156℃), melting point (0.5-1.5℃), decomposing point (165℃), the saturated vapor pressure at 25℃ (6×10^{-4} pa), water solubility at 25℃ (20 mg/l), vapor pressure (1.8×10^{-6} mm Hg) at 25℃, viscosity (37℃*p*) at 25℃, acute oral LD50 (2 g/kg of rat), adsorption coefficient (700) and water partition coefficient of about 4.5 (Abigail *et al.,* 2015). The present review comprised the circumstances of the development of Butachlor generation industries in the field of agricultural applications.

Project identification in Environmental Impact Assessment (EIA)

In Iran, the industrial projects pass through the assessment steps in EIA according to Fig. 1. The procedure is completed by evaluator teams (Hassanpour and Pamucar, 2019). Evaluation is one of the acceptable ways to achieve the goals of sustainable development and can be used as a planning and management instrument for the decision-making sector of countries to identify the potential environmental effects of development projects and select appropriate and logical options. The main purpose of environmental assessment and review is to involve environmental considerations in the planning process. In fact, before choosing a particular option, it is necessary to make a comprehensive analysis of the environmental consequences of each of the options to justify the option that creates the least environmental consequences and is also desirable from a technical-economic point of view. EIA as a management instrument by reducing the correct and rational use of human and natural resources has reduced costs and therefore has a significant impact on short and long term planning of the country and thus can reduce the pressure on government funding. On the other hand, EIA, due to the acceleration of planning stages, provides more protection of resources, and prevents irreversible effects on the environment. Before carrying out any construction project, it is necessary to evaluate the effects of that project on the environment. This is not done to prevent the project from being implemented, but to minimize its adverse effects on the environment is indispensable as much as possible. Industrial development will not succeed in resolving the existing crises without planning on socio-cultural and environmental issues, and it will lose its vitality if it is not accompanied by the protection of natural resources. The United Nations, through the United Nations Environment Program, and the World Bank, through the Department of Health and the Environment, has issued guidelines that must address the effects of that project assessed on the environment, before approving funding for major development purposes. Among developing countries, Asian countries started environmental measures very early and had the EIA system with other countries until the 1980s. EIA Studies for the effects of development are included the positive and negative effects of activities that can, directly and indirectly, emerge in the short or long term effect in the natural and human environment locally or globally as reversibly or irreversibly. The plan predicts, identifies and determines them, and within the framework of the environmental management program, methods of prevention and reduction of adverse effects with appropriate methods are outlined and compensation practices are declared, and then, by selecting the appropriate options for monitoring and auditing professional programs are performed. The data used in this study extracted from the screening step of the project in EIA.

EIA is one of the acceptable methods to achieve the goals of sustainable development and can be used as a plan and management instrument for the decision-making sector of the country to identify the potential environmental effects of development projects. Selecting appropriate and logical options. Evaluation as a management instrument by providing ways of correct and rational use of human and natural resources has reduced costs and therefore has a significant impact on short and long term planning of the country and thus can put pressure on government funding. On the other hand, due to the acceleration of planning, the evaluation will provide more protection of resources and prevent irreversible effects on the environment. In Iran, EIA is a new concept, but in terms of historical background, its signs can be searched under other headings and in a simpler way in previous environmental regulations.

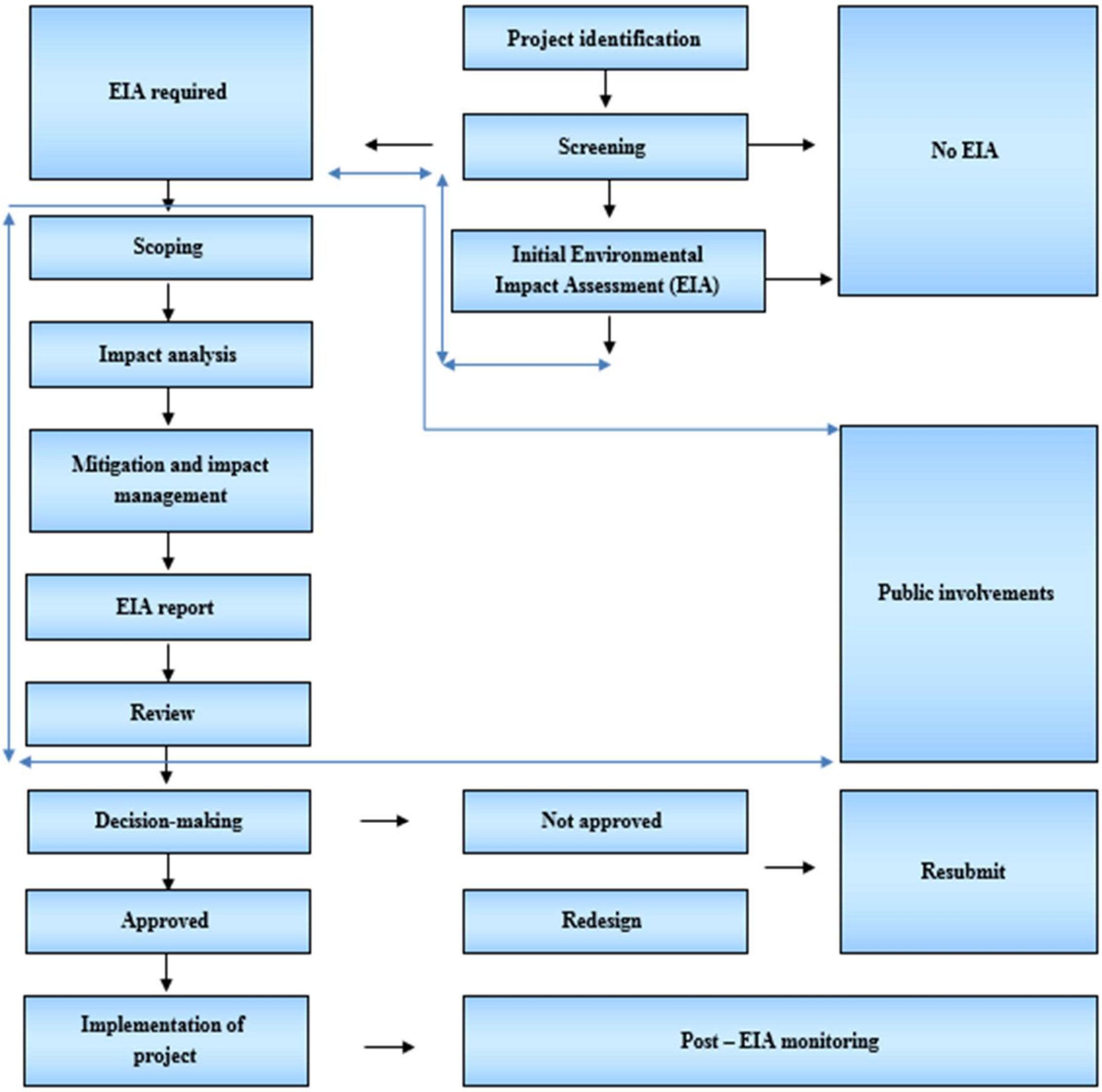

Fig. 1: The assessment steps of EIA (Hassanpour, 2019)

In our country, based on the importance of the issue and following the Environment Protection Organization, the assessment has found a legal status since 1994. A detailed and visual project for motivation or activity is defined by a specific budget that is used to accomplish a specific theme and its purpose is to achieve the goals defined in policies and programs. The goals pursued in the EIA include the following: A instrument for integrating environmental considerations into macro-level decision-making, a systematic approach to integrating sustainability considerations into the planning system, a logical and systematic process for identifying and predicting the environmental effects and consequences of policies, programs and plans, A participatory mechanism to take into account the views of all stakeholders in macro policies, a flexible, diverse and effective practice to improve the effectiveness and sustainability of macro decisions, a method to facilitate the process of identifying development options and provide solutions based on sustainability, identifying environmentally friendly options for sustainable development, identifying key issues and aligning development and environmental goals, strengthening and empowering the sustainability of policies, programs and plans and the global nature of the environment from the presence of elements. The various components of a system arise seamlessly in the formation of the system (Munn 1979; Vallero 2004).

Butachlor (60%) generation technology

Technical herbicides along with petroleum solvents and emulsifiers required for the formulation of this type of product must be combined in a double-walled mixing tank. Adding petroleum solvents can be easily done by a pump that will be installed in the path of their storage tank and the mentioned mixer. Technical herbicides, as they are mainly in powder form (although in some cases, they are also in liquid form, after weighing) they are delivered to the mixer by the forklift and enter the mixer manually. The required emulsifiers, like technical herbicides, after weighing with the help of a forklift in the production hall, they will enter the mixer. The mixer used is selected according to the type of material made from stainless steel and is usually equipped with temperature control devices for the materials inside the tank. Its belongings also comprise the pressure control and a safety valve which are necessary for the second wall. The technique depends on the solvent and the uniformity of the whole product, which does not exceed a retention time of around two hours totally. The transmission channel of primary laboratory products to storage tanks of semi-manufactured toxins is by a pump. However, if solid and suspended impurities are present in the toxins produced, the use of particulate separation filters will be necessary (if the toxins are transparent, it will not be necessary to use this device). The products of each stage of the process enter the tanks after initial monitoring. After filling the capacity of each of these tanks, a sample of it will be sent to the Plant Protection Organization and the lab of the industry for final and accurate quality control tests. Confirmation of the results of the tests performed, packaging of an herbicide produced in different cans (depending on the conditions of use) begins. This equipment, which operates with the help of air pressure has a high packing capacity, includes can fill machine, perforation machine; can lid, and can labeling facilities. The height of the workplace with the ground is about 70 cm and the filling speed and the quantity of liquid required to fill the can is adjusted by the existing control systems. The pumps used in the production line are also used in three parts: to transfer the solvent to the mixer, to transfer the ready toxins to semi-finished storage tanks (possibly passing through filter press), and transmission of toxins after final checking to the packaging machine (Nozhat *et al.,* 2018).

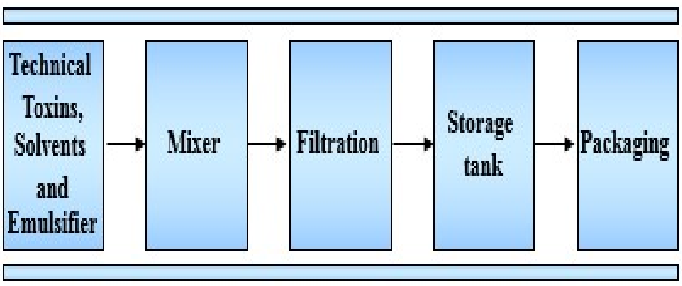

Fig. 2: Diagram of layout butachlor generation units in Iran (Hassanpour 2020a, b)

The centrifugal-type machine has been selected with low pressure and a relatively high flow rate, low supply costs, and very high cleaning capability according to Fig. 2. Butachlor belongs to the acetanilide family consists of shelf life of about 6 to 10 weeks in the soil. Butachlor is used to control thin-leaved annual weeds and some broadleaf weeds of rice fields, especially sorghum. This herbicide is used 4 to 7 days after transplanting at a rate of 3 to 4 liters per hectare, before the two-leafed sorghum (the sorghum seedling must be under the water surface), but indirect sowing before growth (pre-emergence) is used. In addition to rice, butachlor is selectively used on barley, cotton, peanuts, beets, and some cabbage cultivars and can be used in the values of 1 to 4.5 liters of effective substance per hectare. Butachlor depends on the quantity of water available to the plant, so for better results, spraying should be done after rain or irrigation, and care should be taken to block the entry and exit of water for 2-3 days after spraying. The use of butachlor should be used with a prescription from an herbalist and only in the cases described above. Butachlor is not recommended except for the mentioned cultivation and the mentioned weeds. The annual requirements of butachlor generation industries have been displayed in Table 1.

Main annual materials and equipment	Total annual rates
Equipment and devices	
Toxin generation mixer, 1400 L, 3.5 kW	2 No
Filter press, A= 1 m^2	1 No
Pump, 1.4 m^3/h	6 No
Filling machine, 4.5 kW, 1000-4000 NO/day	1 No
Capping machine, 15 kW	1 No
Solution storage tank, 16 m^3, stainless steel	3 No
Pesticide storage tank, stainless steel, 12 m^3	3 No
Materials demands	
Butachlor	510255 kg
Di toxymol	38250 kg
Toxymol AH	8797 kg
Xylene	208500 kg
AL cans	765000 No
Cartons	31875 No
Carton gums	75469 yard
Products	
Butachlor (60%)	750000 Kg
Employees	
Staff	15 persons
Energy consumption	
Required water	6 m^3/day
Split AC (Internal wiring, transformers, and emergency power generators)	87 kW/day
Required fuel (Stoves)	2 Giga Jule/day
Required land and landscaping	
Required land	3300 m^2
Construction of infrastructure (Buildings)	942 m^2

Table 1. Annual requirements of Butachlor (60%) generation industries (nominal capacity of 750000 Kg) (Hassanpour 2020a)

Butachlor elimination processes from aqueous and terrestrial ambient

The main strategies declared in order to eliminate the butachlor from the environment include adsorption, biodegradation, phytoremediation, plasma technology, and nanoremediation with regard to its concentration. The dosage of consumption in the agricultural farms is about 3-4 kg/ha in the Northern provinces in Iran. The butachlor concentration encountered to rise in the rivers, runoff, and rainfalls located to the rice paddies consequently flew to aquatic ecosystems and free seas and oceans. The potential carcinogenic effects will appear on creators shortly (Pourbabaei *et al.,* 2020). Fig.s 3 and 4 present the chemical structure of Butachlor and State-wise consumption of butachlor in India.

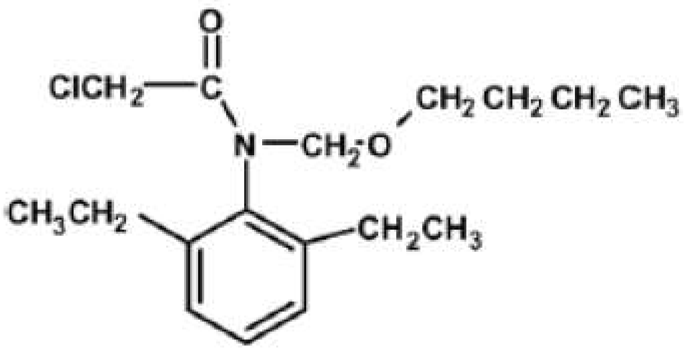

Fig. 3: The chemical structure of Butachlor (Nozhat *et al.,* 2018)

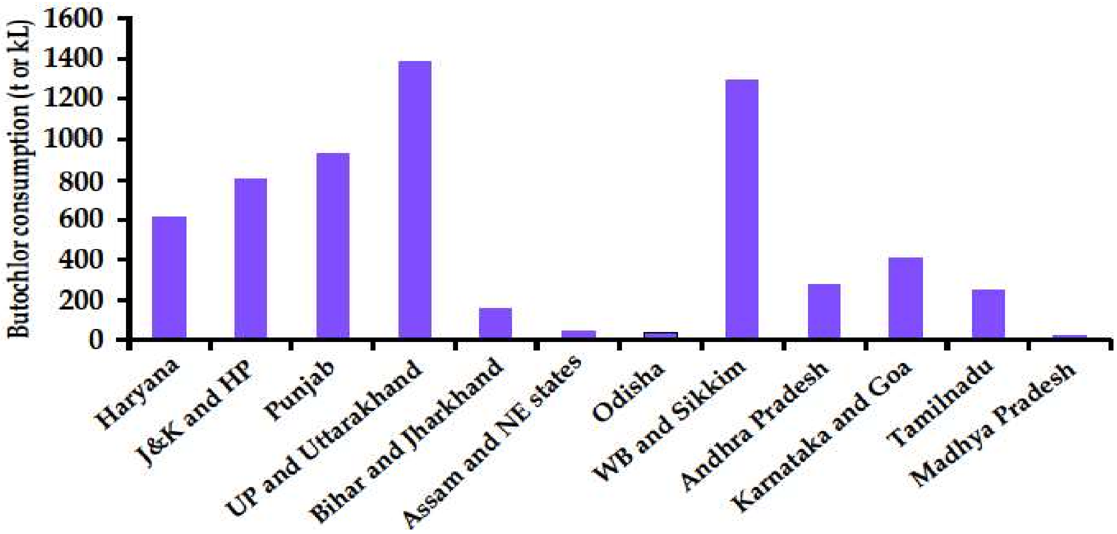

Fig. 4: State-wise consumption of butachlor in India (Choudhury *et al.,* 2016)

To remove the butachlor from an aqueous ambient variety of absorbents are employed. Mahmoodi *et al.,* (2007) asserted the dissociation of butachlor with efficient removal from aqueous ambient via nano photocatalysts immobilized in TiO_2. The adsorbent of GO/Fe_3O_4 grafted with thermosensitive polymer and dendrimer has been a relevant candidate to remove butachlor from a water sample with high efficiency (Mahmoodi *et al.,* 2019). The nascent nano-particles, nanomaterials, and nano-composites are able to remove the butachlor compounds released to aqueous ambient in an industrial spill or agricultural usages (Taran *et al.,* 2021). The use of plasma technology with a variety of reactors, especially hot plasmas, laser beams, rays, and electrical cases are able to remove butachlor from aqueous, outdoor, and indoor air and soil remediations. A variety of air pollution control facilities can be employed to avoid emitting butachlor mists, dust, and aerosols from industrial-scale dissipation. Also, integrated methods and techniques can be used in this regard (Jafari and Hassanpour 2015; Unnisa and Hassanpour 2017). The biodegradation of butachlor is carried out by lots of recently published articles using Pseudomonas species mostly and other types of strains (Mishra *et al.,* 2019). The biodegradation of butachlor has been examined via indigenous Ammoniphilus sp. JF with a thorough breakdown of around 100 mg/L in a period of 24 h of incubation (Singh and Nandabalan 2018). The removal of butachlor has been reported by a study in combination with other pollutants of 2, 4-D, glyphosate, trifluralin by polysulfone membranes mixed by graphene oxide/TiO2 Nanocomposite efficiently. The valorization of butachlor from the soil is another technique to remove it in many studies (Hosseini and Toosi 2019; Nozhat *et al.,* 2018; He *et al.,* 2017). Table 2 shows the butachlor degradation bacteria.

Bacteria	**Source**	**Degradation efficiency**	**Reference**
Arthrobacter sp.	Batch culture and paddy soil	Half-life of butachlor are all not more than 3.68 hours	Wu *et al.,* (2000)
Bacillus amyloliquefaciens	Paddy soil	99.5% with the presence of 20 mg/l butachlor	Zhao *et al.,* (2005)
Rhodococcus sp.		Degrade 100 mg/l butachlor within 5 days	Liu *et al.,* (2012)
Mycobacterium sp. And sphingobium sp.		Syntrophically and rapidly degrades butachlor in 24 hours	Kim *et al.,* (2013)
Pseudomonas stutzeri	Sludge of a membrane bioreactor	Raise in the concentration of butachlor the degradation time increase	Chu *et al.,* (2009)
Stenotrophomonas acidaminiphila JS-1	Butachlor contaminated soil	Complete disappearance 3.2 mmol/l butachlor within 20 days	Dwivedi *et al.,* (2010)
Paracoccus sp. Y3B-1	Activated sludge	Degraded butachlor 65.5% in 3 days	Ni *et al.,* (2011)
Catellibacteriumcae ni sp. Nov. DCA-1 T		Efficiency found 81.2% of 50 mg^{-1} butachlor in 84 hours incubation	Zheng *et al.,* (2012)

Table 2: The Butachlor degradation bacteria

Metabolites	References
• Hydroxybutachlor • 2,6-diethylaniline	Ye *et al.,* (2002)
• 2-chloro-2,6-diethylacetanillide • 2,6-diethylanilline	Chu *et al.,* (2009)
• 2-chloro-N-(2,6-dimethylphenyl) • 2,6-diethylanilline • Aniline • Catechol	Zhang *et al.,* (2011)
• 2-chloro-2′,6′-diethylacetanilide,2,6-diethylacetanilide • N-hydroxymethyl-2-chloro-N-(2,6-diethyl-phenyl) acetamide • 2-chloro-N-(2,6-diethyl-phenyl)-acetamide • (2,6-diethyl-phenyl)-ethoxymethyl-carbamic acid • N-(2,6-diethyl-phenyl)-N-hydroxymethyl-acetamide • N-(2,6-diethyl-phenyl)-N-hydroxymethyl-formamide	Zheng *et al.,* (2012)
• 2-chloro-N-(2,6-diethylphenyl) acetamide • 2,6-diethylaniline • Aniline • Catechol	Kim *et al.,* (2013)

Table 3: Metabolites of butachlor.

The research by Pourbabaei *et al.,* (2020) declared to butachlor degradation microorganisms such as the bacterial strains of Stenotrophomonas acidaminiphila, Paracoccus sp., Catellibacterium caeni, Rhodococcus sp., Mycobacterium sp., Sphingobium sp., Rhodopseudomonas marshes, and Pseudomonas putida and alcaligens, Bacillus licheniformis, Bacillus megaterium, Trichoderma viride, Rhizobium huakuii and Bradyrhizobium japonicum (Abd-Alrahman SH, Salem-Bekhit 2013). The carcinogenicity of Butachlor derived from the metabolic compounds in the dissociation process using sophisticated and natural phenomena. Butachlor with a half-life of 5-24 days, the vapor pressure of 0.6 mPa at 25℃, melting point below 5℃, LD50 of around 3300 mg/kg, the solubility of 20 mg/L (Soluble in common organic solvent), weed control of Echinochloa spp., Fimbristylis spp., and Eleusine indica has been examined and utilized (Singh 2014; Zheng and Ye 2001). The metabolites generated were introduced as carcinogen agents. Table 3 displays the metabolites of butachlor.

Neodeightonia subglobosa IFM 63572 and Sclerotium hydrophilum IFM 63573 have been utilized as breakdown agents of butachlor and accumulated mycelial biomass (up to 0.449 g/L accumulation for N. subglobosa IFM 63572 and 0.214 g/L for S. hydrophilum IFM 63573) and declined the butachlor concentration up to 94.68% for N. subglobosa IFM 63572 and 89.64% for S. hydrophilum IFM 63573) after five days of incubation (Carascal *et al.,* 2017).

The research investigated the Bachelor removal from paddy water in farms in the presence and absence of natural sunlight. According to the findings, the butachlor concentration declined from 355.3 µg/L to 3.9 µg/L for 21 days (Ok *et al.,* 2014). The rhizosphere as a source of dissociation of toxins in plants can facilitate and increase the butachlor breakdown in the soil. Therefore, the area covered by plants will provide soil layers poor in the butachlor concentrations (Abigail *et al.,* 2015).

Butachlor recycling operation and plasma technology

Butachlor decomposes at 165°C but is stable to ultraviolet light. This compound has also been reported in deep well water, groundwater, and wetland water. The non-standard solution of butachlor is produced under unfavorable process conditions in low purity production units. According to international standards, its purity for making formulations should not be less than 88%, so the non-standard products cannot be used in agriculture applications. Storage of this waste is not cost-effective and economical and its disposal causes serious environmental problems. On the other hand, another type of butachlor waste is caused by the filtration of the final product, which is dried in concrete ponds and then buried. The method of disposing of its waste has been prohibited by the Environment Protection Organization. Therefore, butachlor recycling from waste by the solvent extraction method is mentioned as a dominant practice for butachlor reproduction and problem-solving. The recycling of butachlor is done by solvents such as hexane or petroleum ether in a reactor. The extraction of butachlor is done by stirring with a mixer, filtration, rinsing with solvent, and mixing the solution obtained with the original type. The solvent in the solution is separated by rotary distillation. The efficiency of recycled butachlor in weed removal is comparable to that of pure butachlor (Knowles 1998).

In the manufacturing of butachlor is produced wastewater from cleaning, washing of facilities, and processing tanks and is discharged into separate chambers to dispose of. The disposal practices (commercial and traditional incineration, combustion, and pyrolysis) applied are not responsible due to deriving the secondary pollutants that are dangerous in comparison with the initial toxin. The wastewater generated can be utilized to regenerate butachlor with regard to this fact that its content is a mixture of input materials used in manufacturing operation and water. One of the important applications of plasma technology is increasing the crosslinking properties (chemical bonds are broken and chains are transferred to them to improve carriers and surface wetting properties and biocompatibility and the ability of materials to chemically bond). So the butachlor can be retrieved by green additives connected to its structure. It means there is no wastage for this kind of toxins (Musee 2011; council 1996; Denes and Monolache 2004).

Conclusion

Plasma technology is used to generate a green type of butachlor that it is not dangerous in the environment. The application of plasma technology in manufacturing plants needs a real and complete change in the current facilities in the industry. However, we know the green type of some toxins can be produced by lots of additives but many of the products released are inefficient or can not be compared with butachlor. The alternative toxins must provide the same efficiency against weeds and pests. The short half-life of butachlor and degradability in the environment and lack of mobility and penetration in soil layers encourages us to use it in agricultural usages despite the ruling recommendation is to change, replace the toxin with low-dangerous cases. The use of butachlor has been prohibited in many nations even in Iran. The tabulated data of the screening step in EIA can be used in the efficiency assessment and financial estimation in future studies. The sustainability of butachlor industries can be taken into consideration via newly developed technologies for generating green types of toxins. The plasma reactors can remove the challenges posed in the pollutants dissipated from industries. Also, the framework of a circular economy can be implemented using plasma reactors in the manufacturing and recycling of butachlor wastes. The industrial wastewater can be an initial feedstock for the same purpose.

Acknowledgment

This research was conducted as part of the corresponding author Ph.D. research work (Entitled; Evaluation of 405 Iranian Industries). The funding information is not applicable to the present paper. Any opinions, findings, and conclusions expressed in this publication are those of the author and necessarily reflect the current views and policies.

Conflict of interest

There is no conflict of interest.

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