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IRRIGATION SYSTEM FOR AGRICULTURAL LAND. A SHORT REVIEW

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Abstract: *The study is the subject of doctoral research, the purpose of which is to design and implement a sprinkler irrigation system, a system with a dual function, that of irrigating urban and rural areas, soils, agricultural lands and, respectively, that of extinguishing in the event of a vegetation fire, using innovative nanotechnological procedures and advanced nanomaterials.*
The main objective of the research is that both the partial results and the final result of the research are free of toxicity for humans, animals and the environment, considering the purpose of its use. In this regard, the experimental research will be carried out in accordance with the OECD guidelines on testing and with other internationally recognized and validated testing methods in the field of nanotechnology.
The work has the following objectives, in perspective:
- design and development of a "Kit - prototype treatment of sprinkler and the equipment of the watering system with a dual function, for irrigation and/or intervention in emergency situations", with generalized implementation in the Romanian Plain and with experimental application in Talpa Commune, Teleorman County;
- making, development of a nanomaterial (polymer film of the type gel, paint, varnish etc.), through innovative nanotechnology, with the capacity, ability to cover different types of surfaces (metallic or non-metallic – e.g. plastic, glass, ceramics, etc.), for the anti-corrosive, flame retardant (fireproof) and intumescent treatment of the watering system, in order to protect against oxidative factors of the environment and passive fire protection;
- *use of components and a finished product that are non-toxic to humans and nature;*
- *the use of common components, easy to obtain, procure, purchase and with a low cost;*
- *miscibility of components;*
- *easy application by brushing or spraying;*
- *making the sprinkler and the watering system equipment from components with metallic and/or non-metallic surfaces treated anti-corrosively, fireproof and intumescently with innovative nanomaterials.*

This documentary represents the first stage of scientific research, namely the study of specialized literature in the fields of: environment - climate and desertification, nanotechnology - nanostructured materials, agronomy and agriculture - irrigation.

Keywords: *nanotechnology, nanomaterials, agriculture, agronomy, irrigation, sprinkler*

1. INTRODUCTION

The humanity of 21st century is facing serious, profound and perhaps irreversible scientific and technical phenomena and transformations regarding global warming, caused in large part by massive, uncontrolled and abusive deforestation, by the pollution of air, soil and water with toxic agents, by waste and residues resulting from various unmonitored technological processes and, last but not least, by the exacerbated technologization of all areas of life.

The effects of these outbursts of "to Mother-Nature", as a ricochet reaction to the irrational human actions, are difficult to anticipate, evaluate and quantify, in recent years being identified more and more often, and in places where we would not have expected, manifestations of unexpected violence with catastrophic consequences: sudden climate changes, unforeseen transitions from one season to another, and sometimes to extremes, prolonged drought, disastrous floods, hail, landslides, storms, snowfalls in the desert, etc. This cruel and alarming reality requires concerted, systemic and systematic action by global decision-makers on the enhanced protection of the environment from pollution, both for fauna and flora, for the achievement of ecological agriculture, and for the development of environmental agriculture rational use of soil and water and saving the Earth's energy resources. It is a fact found that, although in some places, heating is favorable to the environment, in others, it has catastrophic effects, since it contributes to the expansion of desert areas of the globe and the emergence of new ones.

In this context, it is a fact confirmed and written in the EU Specialized Reports (EU - The European Union – European Union), especially in the last decade, that in Romania there is a risk of desertification of the southern area, including in Teleorman County and neighboring counties [1, 2].

Compared to the above, and in correlation with the findings of research in the avant-garde field of nanotechnology, it can be said today that the discovery of nanomaterials and nanotechnologies has opened the possibility of switching to renewable energy sources, given that all the fundamental stages of energy conversion, change and transfer of electron species, molecular changes and chemical reactivity take place at nanometric scale. Over time, key contributions have been made to sustainable energy supply and global climate protection policy to avoid extreme situations, droughts or floods [3].

The applicability of this research theme is based on several vital arguments, among which one can mention the necessity and priority of the situations identified in agriculture.

One of the most important measures for increasing harvests and ensuring the stability of agricultural production, in the dry areas of the country (with a predisposition to desertification), or where precipitation is deficient and unevenly distributed, is irrigation [4]. Although Romania possesses all types of aquatic units, namely rivers, streams, springs, lakes, groundwater, marine waters, and, at the same time, has a high density of the hydrographic network, its own contribution of water resources generated on its own territory is small (fig. 1), Romania being one of the poorest countries in water resources per square kilometer in Europe [5, 6].

Figure 1. Hydrological representation of Europe

Romania is one of the 13 EU countries affected by the phenomenon of soil desertification, according to an official report by the European Court of Auditors. The area where the situation is critical is also in the south of the country (fig. 2), on the border with Bulgaria (see [2]).

Figure 2. Administrative map of Romania

COMUNA TALPA

Figure 3. Hydrology in Teleorman County

The hydrological network of Teleorman County (fig.3) presents certain particularities specific to the area in which it is located, being formed by the Danube River and its main tributaries in this sector: the Olt, the Călmățui and the Vedea. The county is crossed by the Dimbuvnic, Glavacioc and Câlnișteа streams, which are tributaries of the Neajlov, as well as by the Teleorman River, the Burdea, Căinelui, Clănița, Tinoasa, Nanov and Târnava streams [7].

The Teleorman River constitutes the main hydrographic artery that crosses the perimeter at its southern boundary – west. It has its sources in the Cotmeana Platform, on the territory of the Babana and Mosoaia communes. Teleorman River is a water course, a tributary of the river Vedea, and the river Clanita or the river Clauta is a water course, a tributary of the river Teleorman. Clanita River crosses Talpa Commune (fig.3).

The mentioned water resources (except the Danube and the Olt) are moderated quantitatively and are found in the form of groundwater (water and deep water) or surface water (rivers, natural and artificial lakes). Vedea (120 km) and Calmatuiul (118 km) are the main rivers of the county that, together with their tributaries, drain over 80% of the county area. In the plain, outside the meadow, most of the depressions are occupied by permanent or temporary lakes, many of them desecated (Bercelu, Sarat, Balta Luciei, Red Balta, Cioara, Balta lui Bran, Suhaia, Vartoape, Calugaru, Calina,).

The Danube, a river of European interest, borders the county on a length of 90 km in the southern part (fig.4), representing a great importance for the territory where the water is deficient. The Danube created in the immediate vicinity of its banks a succession of river hail (earth waves, small elevations of land, similar to natural dams, created by the deposition of sediments by the Danube, especially during periods of flooding), and behind them, to the interior formed depressions temporarily occupied by waters, called listeave"(stretched water, water cloudy and sludge flowing slowly over a field, floodable land, muddy, swampy), areas influenced hydrologically by the dynamics of the river (Listea Mare, Mica, Vaslui, Lupilor, Lata, La Plopi, Zimnicea).

Figure 4. Hydrological network of Teleorman County

In the context of the worrying phenomena of climate change, which warns about the risk of desertification, targeting the southern area of Romania, with specific reference to Teleorman County, it is necessary to restore (where possible) or to achieve, as a priority, a system of irrigation that is efficient, sustainable and efficient, including in Teleorman County, to support and protect everything that means Romanian agronomy and agriculture.

The present study aims, as objective in context, experimental prospective works in Talpa Commune, Teleorman County.

As is known, crop irrigation (fig.5) is an agricultural practice that dates back hundreds or even thousands of years in the history of mankind, the main purpose being to provide water to crops, replenishing rainwater or compensating for the lack of water during periods of drought, precisely to increase crop yield and quality.

Water management is now a growing concern in agriculture, whether it is too much water or insufficient quantity. Irrigation systems benefit agriculture by increasing crop yield, supporting higher crop cultivation and water supply according to crop needs [8].

Figure 5. Irrigation of field culture with sprinklers

Irrigation systems provide adequate and necessary crops and food for the population and, in extremis, protect it from the possibility of a serious famine situation, as has happened before in human history.

Types of sprinklers. Selection of the type of sprinkler that will be used in the realization of the watering system network.

Aspersion irrigation systems are some of the oldest methods of surface watering of land. They are suitable for all types of crops, from grain crops to flower greenhouses and are compatible with all types of soil. Moreover, sprinkler irrigation is also the most popular option for watering the lawn. The method is simple and involves the installation extensions - of rain wings - on lengths up to 300-400 meters, on which sprinklers are subsequently mounted. Their range of action can reach up to 40 meters.

Depending on the capacity and the type of spraying, sprinklers are of several kinds:

- specially designed for narrow and long surfaces;
- multi-nozzle type sprinklers, designed for multiple types of irrigation needs and plant species;
- circular sprinklers, which irrigate circularly, as their name suggests, and whose diameter of action and opening can be adjusted as needed;
- rectangular oscillating sprinklers, specially designed for fields having rectangular or square shapes;
- high sprinklers, which are mounted on special tripods, useful for irrigation of plants of higher heights;
- specially designed sprinklers for irregular surfaces, which are mounted so as to irrigate their atypical edges.

To install a system that meets the requirements and needs of the surface to be watered, irrigated or sprayed, several types are known, three different solutions being more important and used [7, 8, 9]:

1. Mobile sprinkler irrigation systems of PE : the pump unit, main pipe and side pipes can be relocated (fig.6). This system is mainly used for fields;

2. Semi-mobile sprinkler irrigation systems in PE: the pump unit and main pipe are fixed, the side pipes can be moved (fig.7). This system is mainly used for irrigation of orchards;

3. Mobile irrigation systems, with wheels, with small, medium or large watering radius, sprinkler spraying (fig.8). This system is used to distribute water evenly and over large areas, saving time, energy and money.

These sprinklers are powerful and intelligent. Most models allow adjustment of the angle of rotation from 45 to 360 degrees, giving the flexibility to adapt irrigation to the shape of the watered surface. Their spraying systems ensure uniform water distribution, avoiding puddles or dry areas. These irrigation systems are effective for large agricultural plantations.

Other types of water distribution systems are:

- Sprinklers with riser or lift, tripod (allow a higher water flow, but also a greater distance between sprinklers);
- Impact sprinklers (allowing the sprinkler to rotate over the entire wetting surface, show resistance to wind, low water consumption, etc.);

- Micro-aspers (allowing to adjust the spray beam and water flow, lead to efficient and uniform watering and a reduction in water loss, show wear resistance, etc.);
- Droppers (water circulates under pressure and has a uniform distribution, etc.).

Pressure irrigation systems are those systems that operate under so-called nominal pressure [9-11], the nominal pressure being defined as the maximum permissible (allowable) pressure that the irrigation system or component can withstand in its entirety, without suffering deformation, or failure (breakdown), and having the guarantee that it will operate safely, in the long term.

Advantages of sprinkler irrigation syste

- Easy to transport and store;
- Easy to handle (manipulation);
- Easy installation;
- Resistant to high pressure;
- To high or low pressure, there`s are no water leaks at the joints;
- Resistance to UV radiation;
- Can be used for irrigation of fields and vegetable crops in open fields;
- Long service life (long lifetime);
- Wide range of diameters from DN50 to DN200.

Disadvantages of sprinkler irrigation systems:

- Higher water loss due to evaporation, compared to drip systems;
- The vortex (Wind) affects the uniformity of irrigation.

Figure 6. Mobile sprinkler irrigation system of PE

Figure7. Semi-mobile sprinkler irrigation system from PE

Figure 8. Aspersor pentru irigatii mobil, cu roti, cu raza de udare, stropire, mare sau medie.

2. RAW MATERIALS AND WORKING METHODOLOGY

Within the theoretical foundation stage, the study focused on the possibility of identifying and establishing the characteristics of the nanomaterial (polymer film such as: gel, paint, varnish, etc.) necessary to be met for the anti-corrosive, fireproof and intumescent treatment of the researched watering system, which is to be designed and practically implemented, in order to protect against oxidative factors of the environment and passive fire protection, as well as the selection of the type of sprinkler that will be used in the implementation of the watering system network.

2.1. Selection of simulation and hierarchy laboratory experiments

2.1.1. Testing and evaluation of physico-chemical and bio-chemical characteristics.

The following properties are considered:

a. Resistance to corrosion, temperature, aging factors of materials (sunlight, UV rays, humidity, etc.), fire;

b. Resistance to photodegradation of binders in coating mixtures prepared in the presence of photocatalytic materials. Evaluation of the photocatalytic effect for coatings made on different types of surfaces (metal, plastic, glass);

c. Degree of toxicity, with reference to the investigation and determination of physical and chemical properties (e.g. size, shape, solubility, etc.), which influence the potential toxicity of nanoparticles, the evaluation of short-term and long-term effects given by nanomaterials, as well as the use of a measurement other than mass to determine toxicity.

Alternative toxicity testing methods are based on:

- "*in vitro*" or *"in silico"* systems - testing is carried out outside the body, in a controlled environment, such as a laboratory: cell cultures, biotechnological procedures, etc.;

- *"in situ"* systems - testing provides information about the characteristics or behavior of a substance or a system by observing it in its natural conditions (direct ecotoxicity assessment, on the aquatic and terrestrial environment, respectively estimating the impact on a single species in a simulated biotope and assessing toxicity on human health);

- *"in vivo"* systems - testing is carried out by observing the effects of a treatment or process, directly on a living organism, to understand how it works in the complex biological context - this is the case of people who accept the experiment on them, on a volunteer basis;

- computer-designed virtual models (virtual models designed computerized).

Alternative toxicity testing methods refer to new approaches, based on ethical and global regulatory principles regarding the avoidance, limitation and even elimination of testing on laboratory animals [12, 13].

With the adoption of REACH (*Registration, Evaluation, Authorisation and Restriction of Chemicals)*, the European Commission published the standardised and accepted methods for testing the hazardous properties of chemicals. These were written in the Test Methods Regulation [18, 19].

In the case of nanomaterials, alternative toxicity testing methods focus on *"in vitro"* tests and strategies developed to assess acute systemic toxicity at the respiratory system level (by inhalation) [13-17].

"*In vitro"* or *"in silico"* methods allow a specific and precise assessment of how substances affect the body at the cellular level, because they comply with global regulatory requirements on product safety and because they lead to the elimination of animal experiments [12, 18, 19, 20].

d. The potential risk level which aims to determine the likelihood that current exposure-response data (human or animal) can be used in the identification and assessment of potential hazards, as well as the estimation of potential exposure to nanomaterials in the workplace [17].

In Romania, the issue of risks related to the use of nanotechnologies and products containing nanoparticles cannot be avoided, requiring a plan of measures and the performance of tests provided for in the European Regulations [(CE) - The CE *Cerfas Conformité Européenne* logo certifies that a product meets the European legislative requirements for health, safety and the environment].

The CLP Regulation provides for the obligation to inform ECHA of substances, in the formulations in which they are placed on the market, including nanomaterials, which meet the criteria for classification as hazardous substances, regardless of their quantity. The Classification, Labelling and Packaging (CLP) Regulation [(EC) No 1272/2008] is based on the United Nations Globally Harmonised System (GHS) and aims to ensure a high level of health and environmental protection, as well as the free movement of substances, mixtures and articles [18-20].

The CLP Regulation amended the Dangerous Substances Directive [67/548/EEC (DSD)], the Dangerous Preparations Directive [1999/45/EC (DPD)] and Regulation (EC) No 1907/2006 (REACH) and, since 1 June 2015, is the only legislation in force in the EU concerning the classification and labelling of substances and mixtures [18, 19, 20].
Regulation (EC) No 1907/2006, known by the acronym REACH, is a European legislative framework regulating chemicals, transferring responsibility for their safety from authorities to industry. Its main aim is to ensure a high level of protection of human health and the environment, while promoting competitiveness and innovation in the chemical sector, and established ECHA [18, 19, 20].

The Dangerous Preparations Directive (DPD) – *1999/45/EC* – refers to a set of European directives, and in the current context, the CLP Regulation is most often referred to, which took over and extended the provisions of the DPD.
The Dangerous Substances Directive (DSD) - 67/548/EEC – refers to a European legal framework that required the classification, packaging and labelling of dangerous chemicals, but which was later replaced by the CLP Regulation.

Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) aligns previous EU legislation with the GHS a United Nations system designed to identify hazardous chemicals and inform users about these hazards. It also provides links to the provisions of REACH.

The following investigations on the materials to be used are considered:
- Atomic Absorption Spectrometry (AAS);
- Scanning Electron Microscopy (SEM) or Scanning Electron Microscopy (STM);
- Atomic Force Microscopy (AFM);
- Dilatometry (DIL);
- Thermo-mechanical Analysis (DMA).

The theoretical choice of possible experimental mass variants was made taking into account:
1. the physico-chemical characteristics of the initial raw materials, from which the research started;
2. the physico-chemical characteristics of the product obtained, which must meet the established criteria, namely a polymer film considered optimal for the creation of the prototype sprinkler treatment kit and irrigation system equipment (irrigation and/or emergency intervention);
3. the established criteria regarding performance, efficiency and effectiveness

2.1.2. The substances expected to be used, selected on the basis of their physicochemical properties, technical data sheets and safety data sheets, are as follows:

I. STIBIUM TRIOXIDE – Sb_2O_3 CAS No. 1309-64-4
II. NAFTOBLEND – mixture of mineral oxides and hydroxides (Naftoblend ACFR-01)

– Zinc borate - CAS No. 1332-07-6

– Boric acid-CAS No. 12767-90-7
– Diantimonium trioxide-CAS No. 1309-64-4

III. ZINC BORATE– Zinc borate does not have a single formula, but several possible formulas depending on the degree of hydration and the ratio of zinc oxide to boron oxides.
The most common formulas include:
- Hydrated zinc borate: – $Zn[B_3O_4(OH)_3]$ ($2ZnO \cdot 3B_2O_3 \cdot 3H_2O$);
- Hydrated zinc borate: – $Zn_2BO_3(OH)$ ($4ZnO \cdot B_2O_3 \cdot H_2O$);
- Anhydrous zinc borate – ($B_2O_6Zn_3$) or ZnB_4O_7, the anhydrous form of zinc borate, without water of crystallization.
CAS No. 138265-88-0 / 1332-07-6 /12513-27-8 /10361-94-1 /12767-90-7
- Zinc borate oxide:– ($Zn_4(BO_3)_2O$) , hydrate (1:1) CAS No. 149749-62-2

IV. BORAX – $B_4Na_2O_7$. 10H2O- CAS No. 1303-96-4
– $Na_2[B_4O_5(OH)_4] \cdot 8\ H_2O$ - CAS No. 1332-28-1
– $Na_2B_4O_7 \cdot 10$ H2O
– $Na_2O \cdot 2\ B_2O_3 \cdot 10\ H_2O$
V. STARCH 1% IND 250 ml – Polysaccharide formed by polymerization of thousands of units of monosaccharide units –glucose, bound by glycoside bonds
– liquid form– $(C_6H_{10}O_5)n$ - CAS No. 9005-84-9/65996-62-5

VI. WHEAT STARCH /FOOD MAIZE – Polysaccharide consisting of amylose and amylopectine
– solid form (powder)– $(C_6H_{10}O_5)n$ - CAS No. 9005-25-8
VII. ALUMINA– Al_2O_3 -CAS No. 1344-28-1

VIII. CHLOROPARAFINE K70 – $C_{24}H_{29}Cl_{21}$- CAS No. 63449-39-8 / 85535-85-9 / 8002-74-2/8042-47-5 /106232-86-4

IX. PVC liquid or soft form– $(-CHCL-CH_2-)_n$ - CAS No. 9002-86-2

X. PVC solid form – powder – $(-CHCl-CH_2-)_n$ – CAS No. 9002-86-2

XII. NANO PROTECT – NANO-PROTECT ® for plastics, for surfaces made of PVC, PC, plastics, protection lotion.

2.1.3. Selected surface

The characteristics of PPR and PVC pipes were analyzed, in accordance with ISO 21003 requirements.

PPR (Poly Propylene Random) is a random copolymerized polypropylene, which is currently the most popular water supply pipe material. The pipes and pipe fittings produced with this raw material have the advantages of light weight, high strength, corrosion resistance, no scaling. In addition to the characteristics of long service life, it also has the characteristics of high heat resistance and pressure bearing capacity, convenient installation, reliable connection (hot melt connection, so as to integrate the pipe), heat preservation and energy saving, non-toxic and harmless.

PVC is polyvinyl chloride, the second most widely used type of plastic after polyethylene (PE), resistant to fire, water, ultraviolet rays, acidic chemicals (less to solvents, such as ether or ketones), with countless industrial applications. Because the chemical additive phthalein in PVC can cause cancer and kidney damage, can destroy the functional reconstruction system of the human body, can affect development, and its resistance cannot meet the pressure requirements of water supply pipes, it is used with caution in water pipes, being generally used for gas or oil transportation, with pipeline or oil pipeline, or in wire and sewer pipes.

Both are, in fact, plastic-based polymers, so they have many benefits in common, but also differences.

One of the differences between PPR and PVC is the durability of the pipe. Although the two are similar in diameter, PPR pipe is stronger than PVC, propylene being an elastic material, while polyvinyl chloride is a brittle material, which makes it even more resistant to shocks, pressure, etc.

PPR fiber composite pipe is made of propylene, with the middle layer being glass, while PVC pipe is based on polyvinyl chloride.

PVC pipes can be used for cold water transport, but the same property is also shared by PPR fiber composite pipe. PVC, however, also has advantages, such as increased corrosion resistance compared to PPR. On the other hand, PPR composite is a type of large-diameter pipe, ideal for large-scale systems, including solar plant pipe networks, as well as those used in agriculture or horticulture [21].

PPR pipes are a widely used choice due to the numerous advantages they offer compared to other materials, such as copper, PVC or steel, because they have increased resistance to high temperatures and pressure, are resistant to corrosion and deposits, have the ability to reduce heat transfer, so PPR pipes offer an advantageous quality-price ratio.
In conclusion, for water transport both PPR and PVC can be a very good choice, the difference being given by corrosion resistance and price [21].

2.1.4. Selecting the sprinkler

One of the best sprinklers for large areas is the pulsating sprinkler with a stake with or without impulse, with a pivot or with a tripod stand. This sprinkler works at both low and high pressure. It can be connected to a 1/2 inch, 5/8 inch and 3/4 inch hose. The irrigation is done at 360° and is convenient to use for irrigating larger areas, thanks to the sliding system [10].

3. CONCLUSIONS

The coating of a support surface with an anti-corrosive, fire-retardant and intumescent protective layer, consisting of one or more elementary nanolayers, allows the modification of the properties of the substrate, in order to achieve predetermined parameters, in terms of:
- resistance to oxidation, corrosion, fire, frost, aging, abrasion, erosion;
- conferring new functionalities in terms of: appearance, polymer surface hardening, hardness, adhesion, acquiring self-cleaning properties.

In the next stage, scientific research will delve into the following topics:
- the effects and impact of wildfires on the atmosphere;
- passive fire protection methods;
- possibilities of intervention in the event of a wildfire.

The realization of the dual-function watering system, for irrigation and fire extinguishing, using innovative nanotechnological procedures and advanced nanomaterials, presents the following advantages:
- involves reasonable costs of realization and maintenance;
- presents accessibility in installation, handling, maintenance and use;
- includes easy and quick repairs in the field, on the affected area and with relatively low costs;
- implies the possibility of immediate intervention in case of fire of dry vegetation or stubble;
- is ecological (eco friendly) by construction and action, both functions being designed for the benefit of people, animals and the environment.

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Acronyms :

CAS - Chemical Abstracts Service – https://en.wikipedia.org
CAS REGISTRY - CAS registry number is the database of chemicals cleaned from scientific literature and other sources. It contains over 290 million substances – https://www.cas.org
ChEMBL - Database of bioactive compounds, their quantitative properties and bioactivities, extracted from the scientific literature. It is part of the resources of ChEMBL from EBI (EMBL-EBI European Bioinformatics Institute) – https://www.ebi.ac.uk.
EC - European Community
CEE - European Economic Community
CLP - Classification, Labeling and Packaging (Regulation (EC) No 1272/2008 on the classification, labelling and packaging of substances and mixtures)
DPD Directive - Dangerous Preparations Directive – 1999/45/EC
DSD Directive - Dangerous Substances Directive - 67/548/EEC
ECHA- The European Chemicals Agency is an agency of the European Union working for the safe use of chemicals – https://european-union.europa.eu
GHS - The Globally Harmonized System of Classification and Labeling of Chemicals, is a United Nations-developed international standard for classifying chemical hazards and communicating them through standardized labels and Safety Data Sheets (SDS).– https://unece.org about ghs; https://eur-lex.europa.eu.
OECD- Organisation for Economic Cooperation and Development, OCDE Organisations de coopération et de développement économiques
PE- Polyethylene
PPR - Poly Propylene Random
PVC - *Polyvinyl chloride*
REACH - Registration, Evaluation and Authorisation of Chemicals – https://osha.europa.eu
UE - The European Union

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