Systematic Literature Review of Microplastics in Bottled Drinking Water in Indonesia

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Abstract

Objective: The purpose of this study was to determine the content of microplastics in Indonesia, the factors that influence them and the impact on the human body.

Methods: This study uses a qualitative method with a systematic literature review approach by reviewing 8 journals that have been screened using the prism method according to the inclusion criteria with a data base derived from science direct, pubmed and google scholar and the vosviewer application.

Results: The results of the study showed that in bottled water, the concentration of microplastics was 7,043 - 8,339 particles/L with small sizes in the range of 1-10 m and large ones in the range of 10-5000 m, where the dominant form of microplastics was fiber and fragments, mostly white with The dominant composition is polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET) polymers. Factors that affect microplastics in bottled drinking water are water sources, production processes, exposure to sunlight and repeated use of bottles. Microplastics can cause hormonal imbalances, risk of heart disease and infertility, digestive disorders, and growth inhibition. Ways to reduce MP particles in AMDK are traditional filtering of raw water, electrocoagulation, magnetic extraction and membrane separation.

Conclusion: Microplastics were found in bottled drinking water in Indonesia with an average of 7,043 - 8,339 particles/L with a composition of polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET) polymers in the form of white pigments and fibers with a size of 1-5000 micrometers. . This is influenced by water sources, production processes, exposure to sunlight and repeated use of bottles, which can harm humans..

KEYWORDS: Microplastics; Bottled drinking water; influencing factors; impact

Introduction

With the development of the times and the increasing growth of society, the need for water also increases. With advances in technology, there are currently many drinking water supply industries that are contained in plastic containers.Based on Aspadin data, bottled drinking water consumption in 2018 was recorded at 29 billion liters per year[1].The use of bottled water has also increased, causing many activities to search for clean water in water in the soil, rivers, lakes, manage water in the sea and restore polluted water.[2]. In Indonesia itself, there was a significant increase in bottled water consumption where in 2005 the consumption

of bottled water was only 4.1% then rose sharply in 2017 to 42.8% and rose again by 10% in 2019[3].

Microplastics are particles that are about 0.3 mm-> 5mm[4]. Microplastics are particles of plastic that are difficult to decompose, this can be caused by improper disposal and handling of plastic waste[6]. Microplastics are not as easy to get rid of as the ocean and plastic is an item that is very marine and plastic is a very persistent material[5].

In a study conducted by Schymanski, from 22 water bottles that were able to return and bottles that were only used once, 3 beverage packages and 9 glasses taken from a grocery store in Germany found small (-50-500µm) and medium-sized (1-50 m) microplastics.) in almost all of the water studied. Nearly 80% of all the items obtained had compound sizes ranging from 5 to 20 mm and were therefore not detected by the analytical techniques used in previous studies. For the amount obtained in the whole sample, there were 118 ± 88 particles in the disposable container, but only 14 ± 14 particles/l contained in the packaging container which was used only once. What is contained in the microplastic in the packaging of beverage storage containers is only 11 ± 8 particles, but the plastic element found was the presence of quite high numbers in several types of glass bottled water (range 0-253 particles/l, average 50 ± 52 particles/l). Statistically significant differences of the blank values (14 ± 13) with the type of packaging investigated can only be shown compared to the returnable bottles ($p < 0.05$). For some elements that are present in the water in the plastic container bottle, it can be given back and re-identify what is there, such as polyester (PET primary polyethylene terephthalate, 84%) and polypropylene (PP, 7%) Statistically significant differences of the blank values (14 ± 13) with the type of packaging investigated can only be shown compared to the returnable bottles ($p < 0.05$). For some elements that are present in the water in the plastic container bottle, it can be given back and re-identify what is there, such as polyester (PET primary polyethylene terephthalate, 84%) and polypropylene (PP, 7%) Statistically significant differences of the blank values (14 ± 13) with the type of packaging investigated can only be shown compared to the returnable bottles ($p < 0.05$). For some elements that are present in the water in the plastic container bottle, it can be given back and re-identify what is there, such as polyester (PET primary polyethylene terephthalate, 84%) and polypropylene (PP, 7%)[7].

The microplastic research conducted by one of the leading universities in New York took 259 bottles of water with the number of water brands being 11 bottles. from various countries with the result that 93% of bottled drinking water is proven to contain microplastics, what is used for some countries is that there is also Indonesia. The samples were about 30 aqua bottles, the results of which contained an average of 325 particles/L for each sample with the highest content reaching 4.7143 particles/L. The size of the microplastics varies from 6.5 m to more than 100 m. The product from Nestle Pure Life is the water with the most microplastics globally with a content of 10,390 particles/L. This is thought to be caused by the process of bottling the water in the packaging and coming from the bottle itself,[8]. As is known from Wright's research, microplastics can cause a series of biological responses including inflammation, oxidative stress, necrosis and affect the human immune system.[9].

Based on this explanation, there are many studies on microplastics in bottled water but not too much is related to bottled drinking water in Indonesia, this study aims to be interested in researching information about the content, factors that affect microplastics in bottled water in Indonesia, and the impact if it accumulates in water. in the human body.

Method

Level of environmental vulnerability

In determining the feasibility of bottled drinking water, there are 3 parameters that need to be considered, namely physical, biological and chemical parameters. Where the physical parameters include turbidity, taste, color, odor, temperature, dissolved solids and microplastics, where microplastics can cause negative effects on environmental and can cause cancer in humans..

Subjects

The population of this study was taken from the database*science direct, google scholar, and pubmed*as muchabout 3090 journals on Google Scholar, 11453 journals on Science Direct, and 7324 on Pubmed according to keywords with samples being screened based on keywords that the author had previously set, based on the inclusion criteria of International and National Journals related to the content of microplastics in bottled water. in Indonesia, the influencing factors, and the dangers of microplastics in bottled water and how to overcome them and the time span of the journal is 5 years (2017-2021).

Research design

This study uses a qualitative design with a literature study approach. *Systematic Literature Review* is a scientific study that describes a predetermined topic, this SLR can make researchers review, analyze and develop theories or methods of certain topics, can also review the gaps that exist between one theory and another with relevance in the field..

Data collection

The type of data used in this study is data that has been obtained from the screening process by combining all data or sources related to the topic under study. This study examines journals and other scientific papers using the PRISMA method related to the content of microplastics in bottled greeting water in Indonesia.

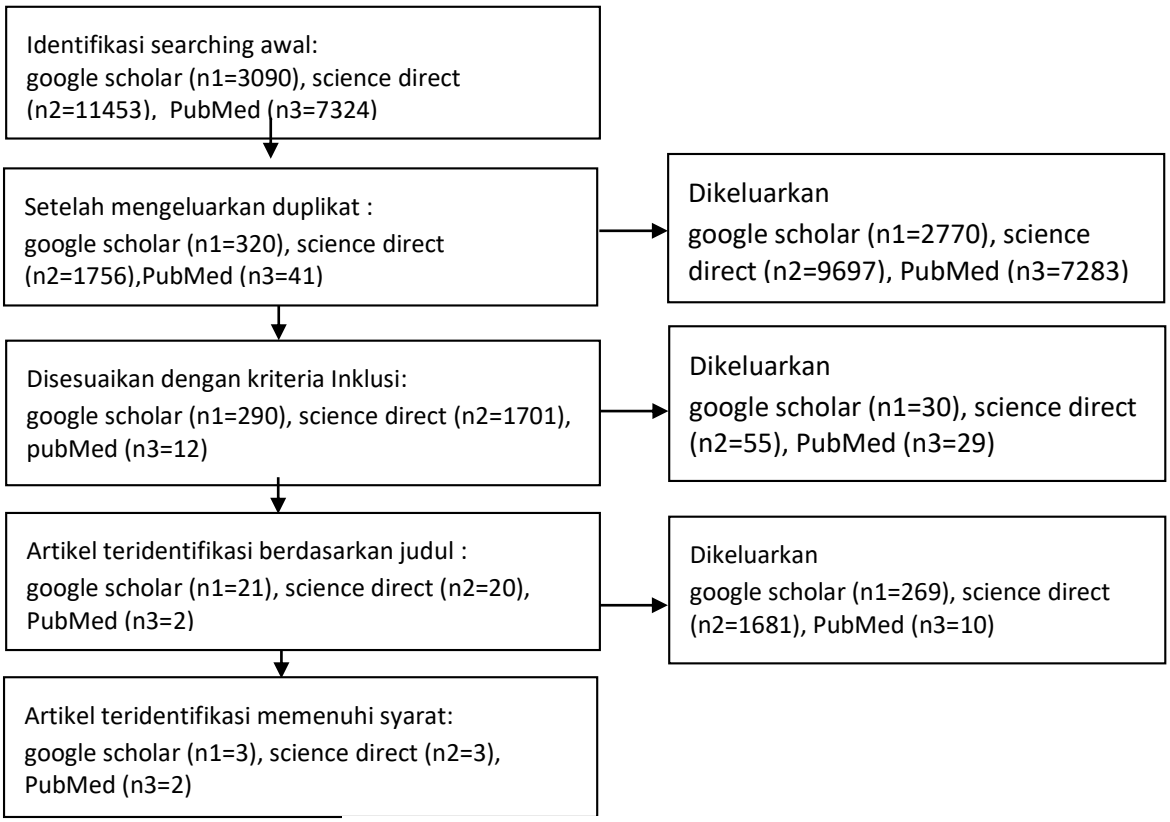


Figure 1 Prisma Flow

Result

Journal results from Prisma Flow with systematic literature review analysis :

Table 1 Systematic Literature Review

Researcher	Title	Sample	Method	Output
(Faujiah, Isma Nur Wahyuni, Ira Ryski, 2022)	Abundance and Characteristics of Microplastics in Drinking Water and Their Potential Impacts on Human Health	43 journals. with journals obtained based on the source, namely Research Gate, Google Scholar, and Science Direct	Descriptive qualitative data analysis	found in the form of microplastic fragments with the type of Polypropylene (PP) as many as 10.4 particles/L with a size >100 m, 335 particles/L with a size of 6.5-100 m; microplastic in the form of fiber and fragments with the types of Polystyrene (PS), Polyethylene-terephthalate (PET) and Polyethylene (PE) with sizes of 0.025-5,000 mm; microparticles of 12 to 58 particles/L with a size of 40 to 723 m; 118±88 particles/L of Polyethylene-terephthalate (PET) and Polypropylene (PP) microplastics and 14±14 particles/L of Polyethylene-terephthalate (PET) types.
(Faizah, Atyaf Umi. 2020)	a Comparative Study About the Amount of Microplastic in Polyethylene Terephthalate (Pet) Drinking Water That Was Exposed and Not Exposed By Sun At Environmental Health Laboratory of Poltekkes Kemenkes Semarang At the Year 2020	AMDK brand X which is a PET bottle Volume 600 ml	Pre-Experimental	There is a difference in the amount of microplastics between PET bottled water that is exposed and not exposed to sunlight. As a form of vigilance, the public is advised to keep PET bottled water away from direct sunlight for both distribution and utilization of other types of PET bottles for other purposes such as water disinfection using sunlight (SODIS).
(Mason, et al. 2018)	Synthetic Polymer Contamination in Bottled Water	239 bottles of bottled water from various brands in China, USA, Brazil, India, Indonesia and Mexico	Experiment	Of the 259 total bottles processed, 93% showed signs of microplastic contamination. After taking into account the possibility of contamination. found an average of 10.4 microplastic particles measuring > 100 m per liter of processed bottled water. With the predominance of Fragment form followed by fiber. Half of these particles were confirmed to be polymeric using FTIR spectroscopy with polypropylene as the most

				common polymer type (54%), used in the common plastics used for the manufacture of bottle caps.
(Shen, et al. 2020)	Removal of microplastics via drinking water treatment: Current knowledge and future directions	15 International Journals	Descriptive	The authors propose that because existing pretreatments that limit the amount of microplastics in water should be adapted to protect drinking water treatment processes.
(Dyah Ayu, Mustikasari 2021)	*Legal Protection for Consumers of Packaged Drinking Water Products From Microplastic Content.*	legislation, official records or minutes in the making of laws and regulations and judges' decisions	Descriptive	The author said that the form of legal protection for consumers related to the content of microplastics in bottled water is contained in Law no. 8 of 1999 concerning the protection and rights of consumers which is meant by the existence of the law can protect the rights of consumers on the bottled drinking water they consume.
(Ivana, Kezia 2021)	Microplastics in Drinking Water	Journal	Descriptive	In the process of manufacturing, storing, marketing to activities when consumed, it has an influence on the presence of microplastics in the water. Being able to enter when water is put into a bottle and providing a cover is also carried out in these activities, it can cause abrasion and remove microplastic elements. Other things, such as physical stress, can cause shaking of the packaging to release microplastic elements in the water.
(Handayani, Risa. 2020)	Literature Review of Microplastic Content in Bottled Drinking Water (Amdk)	Journal	Study of literature	The content of microplastics ranged from 7,043 - 8,339 particles/L. The dominant forms of microplastics encountered were microplastics in the form of fragments and fibers, with the colors found being transparent, light blue, dark blue, reddish brown, dark brown, white, and red; The predominant size of microplastics in bottled water showed the size of small microplastics in the range of 1-10 m, the dominant sizes of large microplastics in the range of 10 - 5000 m. The dominant microplastic compositions found were polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET) polymers.

(Schirinzi, *et a*. 2017)	Cytotoxic effects of commonly used nanomaterials and microplastics on cerebral and epithelial human cells	Cerebral and and Epitel human Cell	Experiment	The results obtained confirm that oxidative stress is one of the mechanisms of cytotoxicity at the cellular level, as has been observed for both cell lines and which is highly likely to cause tissue damage and chronic inflammation.

Based on **Table 1** the results obtained on Google Scholar, there are 320 articles; Based on the title, 290 articles were selected. Then after reading the abstract, 21 articles were selected, and finally 3 articles were selected which would be reviewed by reading the article in its entirety. For Science Direct, there were 1756 articles related to the topic, after entering the inclusion criteria, 1701 related articles were obtained, then after reading the title and abstract, there were 20 journals remaining, which were then taken 3 journals that were worth reviewing after reading them in their entirety. With Pubmed produced 41 journals where after entering the inclusion criteria we get 12 journals, then after reading the title and abstract, there are 2 journals that are worthy of being studied with Systematic Review.

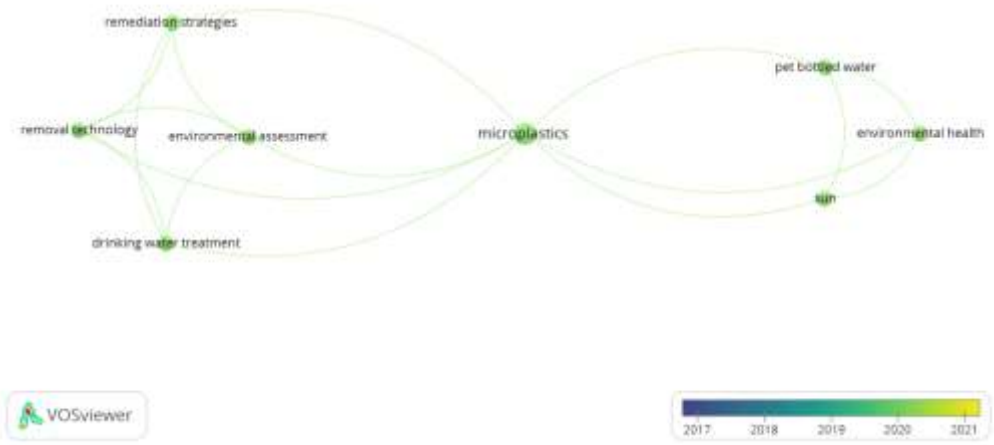


Figure 2 Hasil Vosviewer

VOSviewer is a software that can be used to build and visualize bibliometric networks such as journals, titles, authors, authors, publications and so on.The results of a bibliometric analysis based on the title, keyword and year of the journal that have been carried out using the systematic review and vosviewer method, obtained several keywords related to and influencing the topic of microplastic research in bottled drinking water which includes the elements present in microplastics found in bottled drinking water. that affect it, the impact caused by microplastics on bottled drinking water and efforts to deal with MP in bottled water.

Discussion

The content of microplastics in bottled drinking water

According to research conducted by Faujiah & Wahyuni,(2022)conducted a review of study results in the form of journals related to the theme of microoplastics, their characteristics and types, then focused on the study of microplastics in drinking water and their consequences for human health. With 43 journals obtained from Research Gate, Google Scholar, and Science Direct (El Sevier) with inclusion criteria the journal must have a DOI and at least a journal that has been published in the last 5 years or so. From the review conducted, the authors conclude that microplastics in bottled drinking water are in the form of fragments with the type of Polypropylene (PP) as many as 10.4 particles/L with a size > 100 m, 335 particles/L with a size of 6.5-100 m; microplastic in the form of fiber and fragments with the type of Polystyrene (PS), Polyethylene-terephthalate (PET) and Polyethylene (PE) size 0.025-5, 000mm; microparticles of 12 to 58 particles/L with a size of 40 to 723µm; Microplastic as much as 118±88 particles/L type Polyethylene-terephthalate(PET) and also type is Polypropylene(PP) and 14±14 particles/L type Polyethylene-terephthalate(PET). Then supported by a researcher namedHandayani, (2006)whereThe dominant forms of microplastics encountered were microplastics in the form of fragments and fibers, with the colors found being transparent, light blue, dark blue, reddish brown, dark brown, white and red.[10].

Based on researchMason et al,(2018). Most of the sample bottles were packaged in 500-600 ml, 750 ml, and 2L packages and then randomly selected with a number of 10 bottles, 6 bottles, and 4 bottles in sequence and injected with red nile solution.(prepared in acetone to 1mg mL−1) and resealed. The vials are left to incubate with the injected dye for at least 30 minutes. The bottled water is then vacuum filtered through a glass fiber filter.The filter is examined under an optical microscope using a blue crime light. All particles larger than100 m (which is large enough to be seen with the naked eye and manipulated with tweezers) is photographed, counted and typed with respect to morphology (Fragment, Fiber, Pellet, Film, or Foam). In addition, the first 3-5 particles were analyzed via FTIR. MPinto two volume fractions, called "NR"+"Particles larger than 100 m" identified by FTIR and "NR marked particles" having a size of 6.5-100 m. For “NR + FTIR particles” (>100 m) the mean density was found to be 4.15 MPP/L, with a range of 0–14 MPP/L, whereas in the smaller “NR marked particles” (6.5–100 um) the mean density is 23.5 MPP/L, with a range of 7–47 MPP/L. Of all samples from various countries studied, Indonesia, including 30 samples, showed an average of 325 particles/L with a maximum of 4.7143 particles/L for each sample. The size of microplastics ranges from 6.5 m to larger than 100 m. Nestle Pure Life products have the highest microplastic content in the world, with 10,390 particles/L. With the number. With the total concentration of MP in AMDK in Asia is 333.3; 272; and 119.8 particles/L with a fairly large amount of consumption of (145.66 liters/capita)[8].

For drinking water in proper packaging, it must meet certain criteria where in this case microplastics in bottled drinking water for consumers are regulated in Law no. 8 of 1999 concerning the protection and rights of consumers. With which SNI criteria to become SNI by following normative guidelines, understanding and explanations, quality requirements, by taking samples such as, how to test, with the requirements of passing the test, hygiene, packaging of goods and marking requirements[11].

Factors Affecting Microplastics in Bottled Drinking Water

Bottled drinking water can be contaminated by microplastics because it is influenced by several factors that determine some of them, namely water sources where microplastics can be contaminated from untreated waste disposal, and high pollution in rivers and seas where

filtration can only reduce about 78% of microplastic particles, this study in line with Handayani(2020) . Then the next factor that is quite influential is the production process, according to Weisser et al. (2021) found that the process of entering drinking water, into the bottle, the hydrodynamic pressure on the plastic bottle, especially the process of giving the cap, became the source of the entry of microplastics in bottled drinking water. The packaging of bottled drinking water can also be a factor, there is a big difference between disposable and reusable bottled drinking water with a ratio of 2,659 particles/L and 4. 889 particles/L according to research by Oman et al.(2018). Stress on bottled drinking water also occurs during distribution and consumption and storage by opening the lid many times can cause abrasion of the cap and mouth of the bottle.[12].

According to research conducted by Faizah et al. (2020) that the sample of Indonesian product AMDK is a PET bottle with a volume of 500 ml then with sample preparation a sample of drinking water is taken in 500 ml packaging and the sample will be filtered using whattman filter paper then proceed with the next step. analysis using a binocular microscope with 40x magnification after 2 different treatments, one bottled water was exposed to sunlight and the other was not for 5 hours. The result is that sunlight contains UV rays that can cause mechanical effects on the cracked PET parts, so that the number of MP particles in the affected AMDK becomes more. The average number of microplastics in bottled drinking water that is not exposed is 131.25 particles/liter.[13].

The Impact of Microplastics on the Body and Efforts to Eliminate Microplastics From Drinking Water

Based on research conducted by Shen et al (2020) through a journal review that microplastics can cause toxic effects on the human body. Microplastics can generate oxidative stress and induce tissue damage and chronic inflammation. A review conducted by Wright and Kelly (2017) investigated the potential impact of microplastic uptake on human health through gastrointestinal absorption. The absorption and translocation of microplastics depends on many factors, and smaller particles translocate more effectively, for larger plastics (>2 mm) to stay in the intestinal tract. Although low concentrations of microplastics can enter the blood circulation, it is difficult to enter deep tissues through cell membranes due to their limited size, and is cleared by the spleen.[14]. This statement is the same as what has been researched, namely by Handayani, (2020) where it is explained that MP is able to cause an imbalance between hormones, can cause heart disease and is able to make the body obese and research and Faziah et al. (2020) which states that the transformation of elements that are chemically plastic in body parts, interfere with intestinal microbes to have an effect on the occurrence of blockage of the intestinal tract which results in a feeling of unseen fullness, physiological stress, changes in diet, and growth inhibition.[13].

In research Schirinzi et al.(2017) Observations were made on brain cells and epithelial cells that had been contaminated with microplastics using the testin vitro cytotoxicity by high content analysis. Brain and epithelial cells were stored on 96-well plates and then exposed to microplastic polymers at a size of 10 ng/mL to 10 g/mL for 24-48 hours. At the end of exposure, the tested solution was removed and cells were stained with two fluorescent biomarkers for 30 minutes. at 37 °C in 5% CO2 atmosphere. Then, the labeling solution was aspirated and cells were rinsed with PBS. Fluorescence measurements were determined at emission wavelengths of 485 nm (Hoechst) and 549 nm (DHE) using the Cell Insight NXT High Content Screening (HCS) Platform (Thermo Scientific).[15].

Several techniques and strategies were tried to remove microplastics from beverages (Pivokonsky et al, 2018). Among them is traditional water filtration which in general, traditional filtration process is a promising approach for removing microplastics. For small microplastic particles (up to 1mm in size), traditional filtration strategies are simpler to remove

microplastics from raw water. Circumstances Laboratory conditions must reflect conditions prevailing in drinking water treatment practices. In addition, the particle size distribution of microplastics in raw water and interactions between contaminants and other microplastics are needed to find a better scheme for removing microplastics. Then Electrocoagulation provides a cheaper tertiary treatment method that does not rely on the chemicals or microbes used in common chemical coagulation processes and conventional activated sludge. thus making the coagulation process simple and robust, although there are some limitations in this study, given the microplastic removal efficiency and operating costs, this technique can be transferred and reproduced from the laboratory to industry. Then there is Magnetic Extraction which is a separation technology that uses magnetic seeds and acids with an external magnetic field to increase the speed of separation. The latter is a membrane separation which is often used for advanced drinking water treatment, which has the advantage of being stable Depending on the size of the membrane, Membrane separation technology can be divided into ultrafiltration, nanofiltration and reverse osmosis. The membrane has strong selectivity and separation, which can effectively remove organic pollutants, multivalent ions and disinfection by-products and at the same time, reduce water hardness.[14]

Conclusions

The research results show thatin bottled drinking water has a concentration of microplastics as much as 7,043-8,339 particles/L with a size that is not too large, namely at 1-10 m and a large size of 10-5000 m, where the dominant form of microplastic is fiber and fragments are mostly white with the dominant composition being polypropylene (PP), polyethylene (PE), and polyethylene terephthalate (PET) polymers. Things that affect microplastics in bottled drinking water are water sources, production processes, exposure to sunlight and repeated use of bottles. Microplastics can cause symptoms and diseases such as hormonal imbalance, symptoms of heart infertility, digestive disorders, and growth inhibition. Ways to reduce MP particles in AMDK are traditional filtering of raw water, electrocoagulation, magnetic extraction and membrane separation.

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