Research Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2024.55.008681

Groundwater and Anthropic Activities: A Qualitative Study on Treatment Techniques

Marcos Fernandes de Oliveira[1]*, Bruno de Oliveira Costa Couto[2], Aristeu Gomes Tininis[2], Rebeca Martins da Silva Fernandes de Oliveira[3] and Raquel Martins da Silva Fernandes de Oliveira[3]

[1]*Master's student in Applied Engineering and Sustainability, Brazil*

[2]*Professor, researcher, advisor -IFGoiano-PPGEAS, Brazil*

[3]*Master's student in Bioenergy and Grain Production-IFGoiano-PPBGPG, Master's student in Food Science and Technology- UFG-PPGCTA, Brazil*

***Corresponding author:** Marcos Fernandes de Oliveira, Master's student in Applied Engineering and Sustainability - IFGoiano-PPGEAS, Brazil

ARTICLE INFO

Received: February 08, 2024

Published: February 27, 2024

Citation: Marcos Fernandes de Oliveira, Bruno de Oliveira Costa Couto, Aristeu Gomes Tininis, Rebeca Martins da Silva Fernandes de Oliveira and Raquel Martins da Silva Fernandes de Oliveira. Groundwater and Anthropic Activities: A Qualitative Study on Treatment Techniques. Biomed J Sci & Tech Res 55(2)-2024. BJSTR. MS.ID.008681.

ABSTRACT

The hydrological water cycle comprises constant water movements, which have great influence on the maintenance of vital natural activities. Groundwater in particular constitutes a portion of aquifers, which are considered mobile reservoirs used mainly as a source of supply and human consumption. However, external influences have become largely responsible for the unbalance of the ecosystem, linked to the unbridled human consumption of finite natural resources and the consequent discharge of waste into the receiving bodies without the necessary treatment. The geological water cycle is interrupted when forests are cut down, springs and rivers are extinguished, and together with this, finally, the lack of basic sanitation alters the ecosystem, causing changes of great relevance to the world's population. Groundwater has suffered relevant impacts due to the loss of biodiversity of ecosystems, such as contamination, overuse, lack of current regulatory legislation for use, and the improvement of decontamination techniques. The analysis of the following activities is necessary, mainly due to the anthropic punctual impacts to the ecosystem, corroborating the need for satisfactory techniques. It is noticeable the need for extreme attention to the waste runoff via sanitary sewage to places that have treatment, but the same is not very efficient in retaining this liability, since some developing countries that have not reached about 90% treatment of sanitary sewage, demonstrating the lack of such activities. Thus, the objective of this study is to verify, by means of exploratory and bibliographic research in research bases, the measures that protect the water. Technological measures and sustainable management tools for this purpose will be reviewed, as well as the evolution of groundwater treatment techniques.

Keywords: Groundwater; Exploitation; Decontamination; Ecosystem; Biodiversity

Abbreviations: GRPS: Global Risks Perception Survey; NBS: Nature Based Solutions; O-MnOx: Ordered Mesoporous Manganese Oxide; CAHs: Chlorinated Aliphatic Hydrocarbons; TCE: Trichloroethylene; PCE: Perchloroethylene; ZVI: Zero Valent Iron

Introduction

The role played by water is crucial to the maintenance of various organisms, and relevant because it is a continuous cycle in the maintenance of life on the planet. It is through its hydrogeological cycle that each unicellular or pluricellular individual receives and absorbs nutrients crucial to existence. Starting from the scientific data that only 2.5% of the planet's water is available in the form of fresh water (SILVA, et al. [1]). Of these, 29.9% are concentrated in groundwater, with Brazil holding 13% of this volume (CARDOSO [2]), and that although groundwater in the country totals 112,000 km3 (BORGES, et al. [3]), the lack of proper management of this resource, can cause not future but immediate disruption to the ecosystem as a whole (CARNEIRO, et al. [4]). At each moment the geological water cycle has been compromised (CARNEIRO, et al. [4]), when forests are cut down, springs and rivers are extinguished, infiltration waters are reduced due to less and less space in the planning of cities for this purpose, and finally the lack of basic sanitation and treated water to a large part of the world population, i.e., anthropic activities altering the ecosystem, causing changes of great relevance to the world population.

Groundwater, which a priori became a palliative measure to supply cities, agricultural production lines or in series, but which became a form of confrontation to a water crisis that has increased year after year, and which, due to this use, has suffered the relevant impacts by the loss of biodiversity of ecosystems, such as contamination, overuse, lack of current regulatory legislation for use, improvement of decontamination techniques. In view of the above, the objective of this study is to verify, by means of exploratory and bibliographical research, the search for key words: underground water, more impacts, more techniques and treatment tools, in the Scopus, Periódicos Capes, PubMed, Scielo, BMC and Elsevier databases, with a view to listing measures to protect this resource, water, which is so essential for the maintenance of life. Technological measures and sustainable management tools for this purpose will be reviewed, as well as the evolution of groundwater treatment techniques.

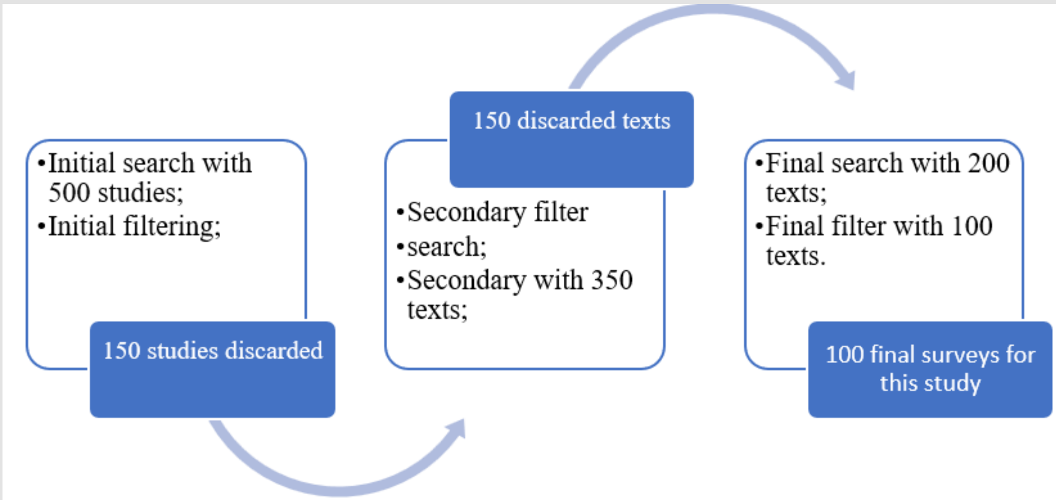
Research Methodology

A global search on groundwater plus impacts and contamination, added to tools for managing water resources and updated remediation techniques for this resource was conducted in a qualitative and exploratory manner in Scielo, Scopus, Elsevier, PubMed, Periódicos Capes, and BMC journals, delimited by the period 2015 to 2022, where 500 studies were found that were filtered again by type of publication, scientific articles, and duplicate papers using the Rayyan support tool, where 150 papers were discarded. Applying a new filter of publications within the area of environmental sciences another 150 papers were discarded, which again using the Rayyan support tool were read and discarded seventy (70) studies for only containing the words but not being specific, thirty (30) for not showing positive results. Flowchart 1 below will demonstrate these steps, and Table 1 in the Remediation Techniques section will show the techniques found and most applied lately for this purpose (Figure 1).

Table 1: Most commonly used techniques in decontamination.

Technique	Description	Methodology	Author	Process	Advantage	Disadvantage
Electrocoagulation, capacitive deionization, electrodialysis, Nanofiltration	is an electrochemical method for separating ions by placing them on an oppositely charged electrode.	The technology works based on the principle of electro-adsorption of ions on the surface of electrically charged electrodes, generally made of porous carbon materials. transformation.	(Moussa, et al. [74])	Separation and reduction	Low cost	Need for post treatment, high energy consumption, secondary compounds
Biological Denitrification	Removal of nitrates by bacteria	Denitrification and nitrifying denitrification are biological pathways that are closely linked by the production of nitrosamines in soils and sediments.	Liu, et al. [76,77]	Biological	High bacterial removal	Low metal removal
Permeable reactive barriers, biofilm--electrode reactor; membrane bioreactor	Removal of nitrates and nitrosamines	Use of biofilms and biomass coupled to electrodes for nitric removal.		chemical--biological	Very sustainable process	No reports
Advanced Oxidation Processes; synolysis; thermolysis; oxidation and reduction; photocatalysis.	Removal of perfluoroalkyl from groundwater	POAs are used similarly to other potable water treatment processes such as membranes, granular activated carbon, air removal and biological degradation.	(Yang, et al. [75]); Zhang, et al. 2015; Zhang, et al. 2011	thermo-chemical process	High removal of perfluoroalkyl (PFAS).	Excessive energy consumption.
Fluorimetry	Removal of Selenium, arsenic, organochlorines, organophosphates, 1,1-dimethylhydrazine, acetonitrile	The technique consists of inserting an analyte (Ce IV) that oxidizes with the compounds present, and the luminescence produced will indicate the presence of the investigated compound.	Liu, et al. [42]; Ateia et al., 2019a , 2019b ; Li et al., 2020; Mastropietro et al., 2021; Wang et al., 2021a , 2021b	photochemical	High accuracy of detection and elimination	High cost, formation of secondary compounds.

Note: Source: Adapted by authors



Note: Source: Own author

Figure 1: Research Flowchart.

Theoretical Reference

WORLD ECONOMIC FORUM, et al. [5], climate change to which no one is immune, nor can the world vaccinate itself against it is ongoing and catastrophic: the "failure of climate action" is the most impactful (GUNJAL, et al. [6]), and second most likely long-term risk identified in the Global Risks Perception Survey (GRPS). Billions of people around the world are at greater risk of missing future economic opportunities, and the benefits of a resilient global community. According to GRPS, "livelihood crises" will be a critical threat over the next two years, and their impact is likely to continue through the decade. (WORLD ECONOMIC FORUM, et al. [5]). The paradigm of the need for the maintenance of biodiversity and the search for socio-economic and cultural sustainability is then created (SENAL, et al. [7]), for the "simple act" of continuing life, and the role of research and development is crucial at this time. Although biodiversity and sustainability are notable terms, their axiomatic concepts (LEÃO, [8]), converge to a common and integrative goal (MAIA [9]). In a recent study PRETI, et al. [10], relate and demonstrate the efficiency of Nature Based Solutions (NBS) and soil bioenergy (BES) as management tools or "naturalistic engineering" as the authors themselves cite, in the remediation, maintenance and prevention of biodiversity loss that has so much influenced climate change.

According to researchers, the (NBSs) are a form of discontinuity of anthropic influences on the environment, and can ensure a sustainable growth (TERTIS, et al. [11]). It is necessary to present the relationship that in a harmonious way should exist between surface waters extremely relevant to the maintenance of biodiversity in all its aspects, mainly in the hydrological cycle of water, and groundwater that also play this important role in the said cycle. This source of surface water replenishment has suffered interference from anthropic activities.

Anthropic Impacts on Subterranean Waters

It is impossible to analyse the unbalance of the ecosystem without adding to it the anthropic impacts caused by man in the search for his constant needs, whether these are salutary to his sustenance or not. And here arises a significant term, the Anthropocene. As HAMILTON [12] describes, the Anthropocene is a rupture between man and nature due to actions in two strands, those able to interfere with the ecological balance of the planet, and those that disturb the system. These disturbances can be punctual or gradual and staggered. When thinking about point anthropic impacts (ALKAN, et al. [13]) to the ecosystem and in the case of groundwater, a supply well used for agricultural production or for a manufacturing unit at 150 mts, 180 mts or greater depths, has a capacity not only local but also regional to affect the ecosystem as a whole, because all the capillarity of small sheets that supply this well, also impact on supply of rivers near the place where the point of collection of this water is installed. According to ELIAS [14], the study Anthropocene is a current proposal although not so young, the author through paleoclimatological studies has observed the physical and biological global response to this phenomenon, drawing attention to the concentrations of CO_2 and its direct implications to life. It is a fact that, mainly due to the unrestrained growth of industrial activities, the interference of waste generated and disposed of in environmental spaces is huge.

A relevant issue raised by MANÇANO, et al. [15], when they address in their study the excessive use of antibiotics used constantly in the production of animal protein, as by humans through self-med-

 DOI: 10.26717/BJSTR.2024.55.008681

ication and the implications of this waste in the micro cellular biochemical structure present in wastewater. The authors draw attention to the residue drained via sanitary sewage in locations that have treatment, but which is not very efficient in retaining this liability, as in places such as developing countries that have not reached 100% treatment of sanitary sewage. Extreme environments according to DUSSAUZE, et al. [16], in their study directed to points of oil exploration, suffer the action of chemical dispersants that interfere greatly in the marine ecosystem. Gradual or staggered impacts can be observed through the change in the rainfall index of a region, or the development without proper planning of an urban area, where the lack of a master plan for constructions, geomorphological risk, erosions (PONTE, et al. [17]). Study, map and define these factors is crucial for decision making. They cite MANCINI, et al. [18], in their study in Italy, direct implications as the above on groundwater quality, through four different statistical methodologies where change points, trends, percentile and non-standard anomalies were evaluated to detect inter-annual variations in rainfall amplitude in the region.

With four defined objectives to compare statistical methods in rainfall assessment, identify the relationship between evapotranspiration and infiltration, the temporal variation of the rainfall index and describe critical situations of depletion. According to the authors report, anthropic impacts and climate change are amplified due to the extrapolation of groundwater use, and the loss of natural vegetation cover directly influences the infiltration volume and replenishment of groundwater springs. Study in Nigeria conducted by ETUK, et al. [19], corroborates the discussion raised so far, the researchers analysed Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of vadose zone, and hydraulic conductivity (Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of vadose zone, and hydraulic Conductivity-DRASTIC). Identifying nitrate values (HUNOOR, et al. [20,21]) higher than allowed even in the saturated zone, and the reasons that are already well known among them, the region had a population increase in the order of 400% in the period between 200 and 2020.

The researchers warn about the constant pressure exerted by food production, which consumes 73% of the fresh groundwater in rural areas and 43% in urban areas of the planet, and the direct effects of this extreme use could very soon compromise the recharge zones of aquifers. They propose HUTSON, et al. [22], in their study, the adoption of a healthy urban planning that can absorb the needs of citizens and regional socioeconomic growth in such a way that both sides of coexistence can be met in their longings. Increasing the spectrum of discussion, the study by ASADZADEH, et al. [23], shows us an issue of paramount importance analysed in their work through remote sensing of the levels of hydrocarbons found in the state of Bahia and in other locations. The objective was the verification of macro and micro infiltration into the soil of aromatic and aliphatic hydrocarbons, frequent contaminants in groundwater of difficult removal. The relevance of this study is in the origin and form of contamination of aquifers (SOUSA, et al. [24]), not in a traditional way by the hydrological cycle of water, but by the formation of units "macroseps" that allow the infiltration of gas forming a plume of contamination, of clay, carbonate precipitation, sulfides and other contaminants.

The researchers report in the study that after collecting samples and analysing the spectrum, there was an elongation of the side carbon chains and an overlap of the π and δ bonds of the compounds found, as well as a resonance in these compounds, which means the even greater need for energy to be offered for decontamination of this affected sector. It is observed then, that anthropic impacts are felt by the ecosystem (SILVA GOMES, et al. [25]), from the terrestrial atmosphere to the deepest oceanic point, with direct implications on the ecosystem, biodiversity, causing substantial chemical, physical, biological and microbiological changes (LEÃO [8]), groundwater (BASTOS, et al. [26]), in the remediation of impacts by necrochorume (OLIVEIRA [9]), in mining activity (CRISTINA, et al. [27]), as well as in soil permeability increasing the infiltration area and groundwater recharge (AURÉLIO, et al. [28]).

Evolution of Groundwater Remediation Techniques

In their study PROPAGADORA ESDEVA, et al. [29], show us the crucial importance of the water renewal cycle, reporting the relevance of evapotranspiration in this process and the liabilities generated by anthropic activities for the maintenance of the water renewal cycle. Although, from a simple observation point of view, surface waters, rivers, lakes, oceans and polar continents - Arctic and Antarctic - are observed, it is also necessary to know the substantial index of subterranean and freshwater suitable for consumption that exist throughout the planet, which are natural repositories of surface waters that we observe (VENTAPANE, et al. [30]). These underground complexes are the result of hydro geological formations dating back to the periods: Jurassic, Cretaceous, Cenozoic - Quaternary, Tertiary Quaternary (SANTOS, et al. [31]); and are hydro geological formations capturing surface water of varying depth, and can reach up to 180 meters deep (HARMON, et al. [32]). The authors also show us that these percolating surface waters are influenced by the lithography of the region and drag along the lower levels the contamination or chemical composition existing on the way to their destination.

Preliminarily characterized by (CONAMA [33]), where the waters were also classified into 5 different types according to their quality and degree of potability, with support in Law 9.433 of 1997 that establishes the criteria for use and consumption, criteria that were improved later by Resolution 153 of the Ministry of Environment (BRASIL [34]), which at this time already notes beyond the standards of potability, the need for controlled use, monitoring and decontamination of this resource and establishes deadlines for investigation, bodies responsible for this supervision and monitoring, only leaving open the methodologies to be used for such. It is worth noting that

 DOI: 10.26717/BJSTR.2024.55.008681

the type of soil, its coverage, the type of native vegetation (YU, et al. [35]), its grain size and porosity, the form of use has fundamental importance in the characteristic and quality of groundwater, because the soil, a natural structure, complex and composed in its formation by phases: solid, liquid and gaseous (VILA, et al. [36]). With a specific and varied granulometry, a chemical composition formed in the biogeochemical process where there are parts of the "Mother" rock of origin, but also has characteristics and materials coming from processes of decomposition of a diversity of sources such as fruit, dead animals (SANTHIYASRI, et al. [37,38]), microorganisms, small animals that are responsible for assisting in the chemical and biological synthesis so necessary for its exploitation and use as a source of energy and food.

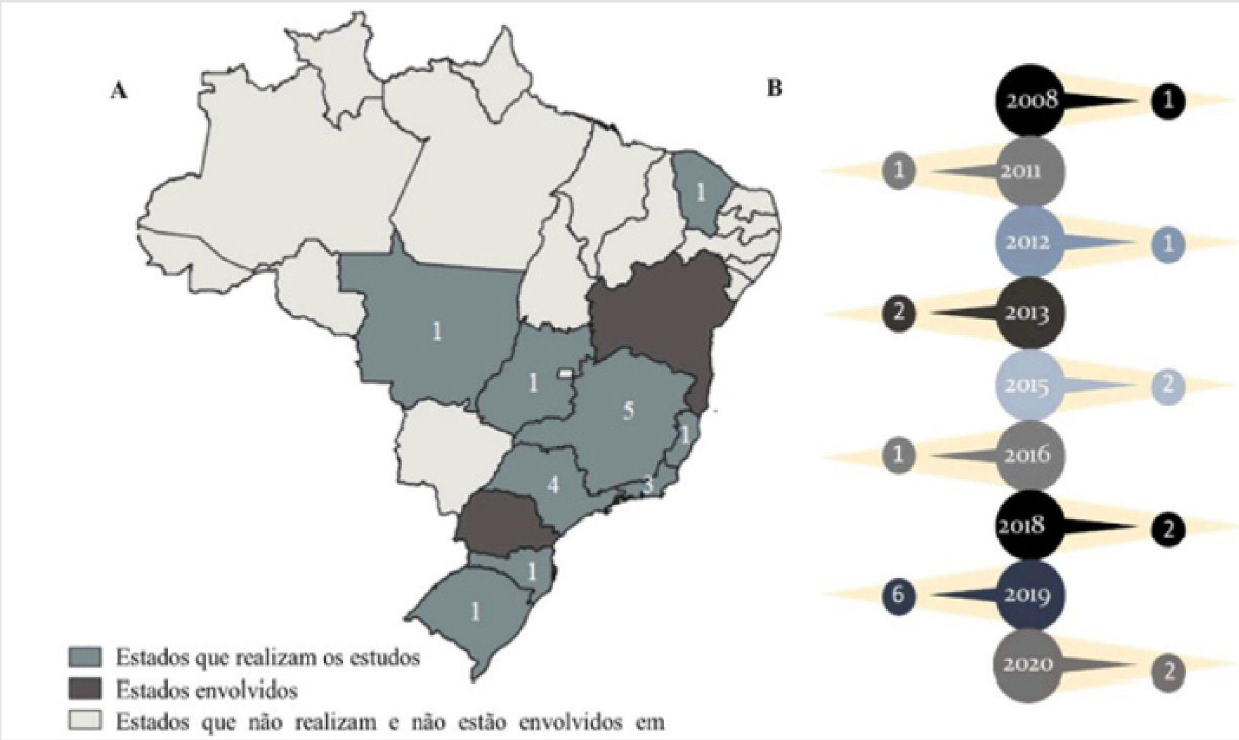
Classified as: Latosol, Lithosol, regosol, hydromorphic, podzolic and podzozalid, where these classifications are directly linked to pH (NAYEEM, et al. [39]), and the quantities of macro and micro minerals in its composition. Added to anthropic activities create an environment of risk to the quality and potability of groundwater. (EMBRAPA SOLOS 2013). Regions with vegetation cover provide the interception process of this recharge from rainfall (FU, et al. [40]), retaining part of the water volume for maintenance of seedling structures and soil microbiota. Without the protection of remains of leaves, fruits, stems and small animals in decomposition, the infiltration process is faster and is conditioned to the characteristics of the type of soil, its granulometry and absorption capacity. The researchers BRITTO, et al. [41], draw attention in their study on the influence of demographic expansion of cities and the lack of planning for this, as well as its inherent impacts on the hydrological cycle of water, the decrease in recycling capacity of water held through infiltration points for supply of groundwater and groundwater. This natural decomposition cited by (VILA, et al. [36]) in itself already produces a substantial contaminant load to groundwater, although the growth of cities, the increase in cultivated areas and the lack of an effective land use policy are increasingly affecting the quality and potability of these geological water catchment formations.

Groundwater Remediation and Treatment Techniques

Table 1 below demonstrates the most relevant and reproducible techniques used and found in the literature. In their review LIU, et al. [42-44], show the efficiency of some techniques most used in the remediation of groundwater contamination by nitrates and halogen compounds linked (CASTRO SANTOS, et al. [45]), to carbonic chains, reporting their difficulty of removal by the formation of secondary compounds (TIWARI, et al. [46]), or even by the residual effect generated to the water repositories, these researches show that the rate of use of this resource has increased a lot and that complementary studies and improvement of the techniques and the set of them for decontamination of this reserve are necessary. As shown by. HYPOLITO, et al. [47], when they demonstrate the use of the technique of electrochemical remediation (ZHOU, et al. [48]), for treatment of ions dispersed in contaminated soils and with the possibility of contamination of aquifers. As reported by the authors themselves, the technique is satisfactory although its coverage in depth is low due to the electrodes that are inserted into the soil and receive electrical charges at opposite poles aiming at the decontamination of this area. The researchers affirm TEDESCO, et al. [49], that the vulnerability of these aquifer areas is closely linked to environmental contaminants (YAN, et al. [50]), the use of the soil, whether agricultural or in urban centres by industries and by the discharge of wastewater without proper treatment, increasing the vulnerability of aquifers and showing the latent need for refined techniques of decontamination of this source of surface water replenishment.

What is also corroborated by SILVA, et al. [31], in their study of monitoring the vulnerability of the Araripe sedimentary basin in northeastern Brazil, the authors also report the volume of groundwater collected annually of 17.5 km3 of water in tubular wells and that the quality of this water needs monitoring and adequate treatment for consumption. Even though the country still needs more dissemination in research and development for monitoring and treatment of this resource (CHEN, et al. [51]). The use of this resource as TUNDISI, et al. [52], which is noted in the Brazilian reality are monitoring studies (COOPERMAN, et al. [53]), where the quality and potability are evaluated along with the vulnerability of the groundwater resource (LI, et al. [54]) and few experiments related to the treatment of this resource or improvement of techniques for this purpose as has been noted in studies already published. In Brazil as reported by RIBAS, et al. [55], in their recent study that, although with the national water resources policy and the national basic sanitation plan already in full operation, both the number of municipalities covered by basic sanitation is low and the lack of technology meet the needs of treatment of wastewater that percolates to the subsoil is still slow and with little research and development in the sector, with the major impulses coming from public research entities and still low in number as shown in Figure 2.

 DOI: 10.26717/BJSTR.2024.55.008681



Note: Source: (RIBAS, et al. [54])

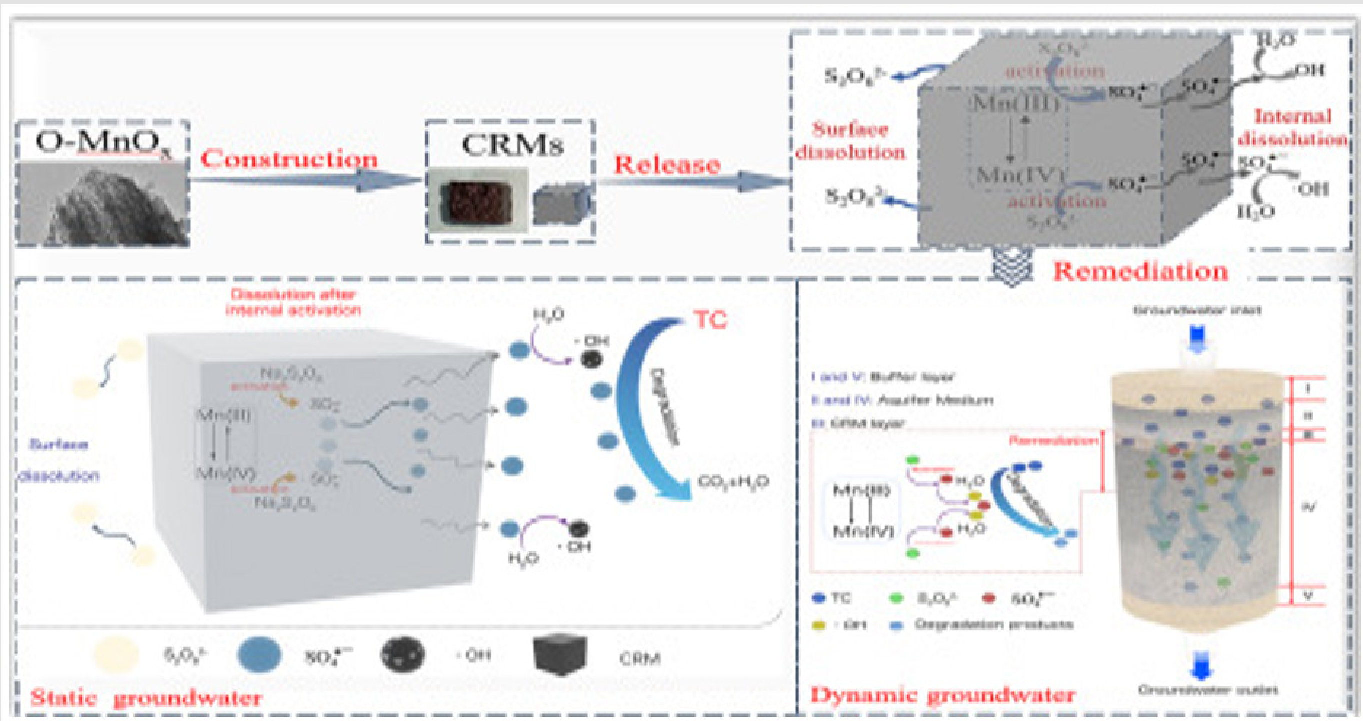
Figure 2: Studies on national water resources policy and the national sanitation plan.

In their review BAO, et al. [56], report the use of a set of techniques added to ionizing radiation for the treatment of recalcitrant organic compounds, which are difficult to degrade, hydrophobic and bioaccumulative (KUMAR, et al. [57,58]), with high chemical and photochemical stability and low biodegradability rate. They are polychlorinated biphenyls, DDT, dieldrin, dioxins and phthalate esters. Advanced oxidation processes, electrochemical oxidation, ozonation, combined with ionizing radiation at low frequencies have produced satisfactory results for aquifer decontamination. (BAO, et al. [59]). Although promising, this process brings direct and indirect effects, the direct effects are the ionization of the target compound, and indirectly the radiolysis of the solvent merges with the target compounds (KANG, et al. [60,61]), to form a chemical transformation. A pertinent discussion about atoms and molecules is regarding the construction of their electric charges of electrons and their nuclei. It is important to know the amounts of energy resulting from the electrostatic interactions of these charges in the dosages of this type of treatment. (PACCHECO, et al. [62]). As shown by BERTAGI, et al. [63], in their study on the application of persulfate as a technique for remediation of contaminated groundwater the chemical interactions resulting from the process are important and depending on the type of soil, the geological formation of the subsoil interfere directly in the remediation process, as the authors show in the equation forming the superoxide ion.

$$S_2O_8{}^{-2} + H_2O \rightarrow 2SO_{4-^2} + HO^{-2} + H^+ (2)$$

$$HO^- \; S_2O_8 2^- + HO^{-2} \rightarrow SO_4{}^{-2} + SO_4 -\bullet + O_2 -\bullet + H^+ \; (3)$$

A discussion is pertinent with the application of persulfate in ions of the first transition row elements, as the energy offered by the process that provides the emission of the photon from the molecular orbitals dx2 dz2 and dy2, Fe, Co, Ni, Cu and Zn allow this homogeneous activation. Another technique is shown by WANG, et al. [64], when they use ordered mesoporous manganese oxide (O-MnOx) and sodium persulfate (Na 2 S 2 O 8) in the removal of tetracycline from groundwater in static and dynamic environments. Chlorinated aliphatic hydrocarbons (CAHs) such as trichloroethylene (TCE) and perchloroethylene (PCE), which are widely used as organic solvents in industry, have become a source of groundwater pollution. In their study, YUAN, et al. [65], report on the use of zero valence iron coupled to autotrophic hydrogen batteries as precursors in the removal and degradation of these compounds. The authors demonstrate in their study a good efficiency in a period of 20 days with chlorine removal percentage reaching 75% and 100% in 60 days, although the dechlorination has been incomplete, which can generate a secondary contamination and therefore further studies are needed for deepening. Working with hexavalent chromium removal in groundwater HAN, et al. [66], report how micron zero valent iron stabilized (SCHERER, et al. [67]) with xanthan gum has been promising in the removal by electron transfer of chromium in groundwater contaminated by this highly toxic metal (Figure 3).



Note: Source: (WANG, et al. [63])

Figure 3: The process of degradation of quality water by CRMs containing OMn is a static system of quality water in TC-um.

The authors describe that in a direct comparison of zero-valent micron iron with nanovalent iron, which is widely used in groundwater metal removal, the cost of micron iron is about one hundred times lower, with a higher efficiency rate although the particle size is larger which results in low suspension stability and underground transportability. Nano particles have been increasingly used in in situ bioremediation or oxidation processes in groundwater (PANDEY, et al. [68]), the costs are lower although several doubts still remain about the side effects (TIAN, et al. [69]), the addition of microorganisms (IKHLAYEL [70]), (KATARIA, et al. [71,72]) can increase the number of pathogens in aquifers, the backscatter that can occur by the adsorption of sand grains (MOFRADNIA, et al. [73]), another difficulty encountered in in situ treatments are the tailings that can form the plum effect thus increasing the contamination plume.

Results Found

Electrocoagulation, capacitative deionization, electro dialysis, Nano filtration, are electrochemical methods to separate ions (MOUSSA, et al. [74]) by placing them on an oppositely charged electrode by a process of chemical separation and reduction. The technology works on the principle of electro adsorption of ions on the surface of electrically charged electrodes, usually made of porous carbon materials. It has a low cost, although it requires post treatment, has a high energy consumption and the possibility of forming secondary compounds. In this same line of treatment the chemical reduction of the contaminant, a chemical and biological process, which depending on the strength of the electron donor of the probe molecule and the acidity of the hydroxyl group, there is interaction by hydrogen bonding or proton transfer to the probe molecule. In the chemical reduction process, zero valent iron (ZVI) is used as the main electron donor studied reduce nitrate to N 2 through redox chemical transformation (XIN, et al. [75]). (LIU, et al. [38,76]). Another procedure is Biological Denitrification, which is based on the removal of nitrates by bacteria, (LIU [76]) and (ZHANG, et al. [77]), studied this biological process, because, denitrification and nitrifying denitrification are biological pathways that are closely linked by the production of nitrosamines in soils and sediments.

Still in this segment of biological studies,, show us the techniques of Permeable reactive barriers, biofilm-electrode reactor; membrane bioreactor (BENEKOS, et al. [78-80]), in the reduction of nitrates and nitrosamines, a chemical and biological process, through the use of biofilms and biomass coupled to electrodes for nitrate removal, a very sustainable process , and that according to the authors, until its publication had not been found results that disabuse its use. Advanced Oxidation Processes; synolysis; thermolysis; oxidation and reduction; photocatalysis, are thermochemical processes, used in the removal of perfluoroalkyl from underground waters. POAs are used similarly to other drinking water treatment processes such as membranes, granular activated carbon, air removal and biological degradation. Thus (LIU, et al. [42,81-83]), show us these processes in the removal of perfluoroalkyl (PFAS), and (KOZLOVA, et al. [42,84,85]), complex substances of high rate of contamination to groundwater, and although they have a high degree of efficiency, in the proportion of 95%, have in their disadvantage a high energy consumption for effectuation.

Discussion

Processes of separation and reduction of ions, biological, chemical - biological, and thermochemical demonstrate according to the authors researched specific efficiency in the remediation of contaminants, although its passive formation of ammonia (chemical reduction of contaminant), low reduction of metals (denitrification), the need for post treatment (Electrochemical), the advanced oxidative processes (thermochemical), show a high efficiency of perfluoroalkyl removal, although in all the processes mentioned there is a high energy consumption for execution and formation of secondary compounds, which, depending on the treatment technique implemented by the drinking water utility, will not be removed from the composition of the water offered. The Fluorimetry technique, on the other hand, has a high detection and elimination rate of Selenium, arsenic, organochlorine, organophosphorus, 1,1-dimethylhydrazine and nitrile acetate, highly toxic, carcinogenic compounds with a high impact on the environment. However, the cost of the execution of this technique is high, thus imposing barriers to its implementation in underdeveloped or developing countries, where these compounds are found in wastewater due to the widespread use of pesticides.

The combination of techniques may be an effective alternative for groundwater resource protection, combined with stricter legislation on groundwater use, and complemented by implementation of "naturalistic techniques" for soil protection (AJALA, et al. [71,86,87]). Regions with vegetation cover propitiate the interception process of this recharge from rainfall, retaining part of the water volume for maintenance of seedling structures and soil microbiota (MARGRET, et al. [39,72]). Without the protection of remains of leaves, fruits, stems and small animals in decomposition, the infiltration process is faster and is conditioned to the characteristics of the soil type, its granulometry and absorption capacity. The researchers BRITTO, et al. [41], draw attention in their study on the influence of demographic expansion of cities and the lack of planning for this, as well as its inherent impacts on the hydrological cycle of water, the decrease in recycling capacity of water held through infiltration points for the supply of groundwater and groundwater. These points are set out in Resolution 153 of 17 December 2013, established by the Ministry of the Environment through the National Water Resources Council, which establishes guidelines for artificial recharge of aquifers in the Brazilian territory.

Final Considerations

The knowledge of rock architecture as cited (RAN, et al. [88]), as well as the study of the relationship between biomarkers for leachate percolation (KODA, et al. [89]), the interactions occurring between sediment-vegetation-infiltration (BEBINA, et al. [90]), are supports for the need for in-depth knowledge of the characteristic and contaminant of the groundwater resource. Another relevant correlation shows us VOLCHEK, et al. [91-97], in his study on the environmental flow of rivers, the protection of ichthyofauna, in the water regulation of biocineses. because as the authors show, the relationship between the environmental flow of a river focuses on rainwater and replacement groundwater to maintain the water flow. In this study carried out globally, aiming at the knowledge of techniques and tools for water management, it was realized that:

a) There are inflection points among much of the techniques found, such as high energy use, implementation cost, selectivity, specificity;

b) There are implementation costs that, for developing countries, become difficult to implement, although necessary because of the high index of contaminants coming from mining, vegetable and animal protein production;

c) It is necessary to adopt norms of Exploration of the resource that is subterranean water, as well as an adequacy to the analytical methods of treatment to minimize contaminants;

d) More complementary studies are necessary so that the techniques can be used more satisfactorily.

Because it is a broad review where the remediation and treatment techniques were listed, it is necessary to complementary study for the techniques found, its immediate and lateral implication in the ecosystem and its impact on biodiversity.

References

1. Silva J F DO A, Pereira RG (2019) Panorama global da distribuição e uso de água doce. Revista Ibero Americana de Ciências Ambientais 10(3): 263-280.

2. CARDOSO FC (2018) Estudo de aproveitamento de água de chuva no condomínio Dona Lurdes Piacentini em Campo Mourão-PR. Trabalho de Conclusão de Curso Campo Mourão UTFPR.

3. BORGES AS (2021) Abordagem Sociohidrogeologica para Avaliação dos Usos das águas subterrâneas em comunidades rurais. Dissertação de Mestrado—Ilha Solteira: UNESP Universidade Júlio Mesquita.

4. CARNEIRO GCA, Dimária Aparecida Fernandes Dias, Eliny Rodrigues Fonseca, José Augusto Costa Gonçalves (2020) Contaminação das águas subterrâneas por compostos orgânicos na bacia hidrográfica do rio das Velhas, no estado de Minas Gerais, Brasil. Research Society and Development 9(10): e3109108536.

5. (2022) WORLD ECONOMIC FORUM. The Global Risks Report (17th Edn.).,.
6. GUNJAL A, Shruti Gupta, Eyiuche Julius Nweze, Justus Amuche Nweze (2023) Chapter 4 - Metagenomics in bioremediation: Recent advances, challenges, and perspectives. In: KUMAR, V, et al. (Eds.), Metagenomics to Bioremediation. Developments in Applied Microbiology and Biotechnology. [s.l.] Academic Press, pp. 81-102.
7. Senal M I S, Bo V Iversen, Søren O Petersen, Lars Elsgaard (2022) Heterogeneity of nitrate reduction indicators across a tile drained agricultural catchment in East Jutland, Denmark. Geoderma Regional 31: e00579.
8. LEÃO, M (2022) Avaliação Química da Água como Subsídio à Avaliação de Patologias na Estrutura de Concreto de uma Barragem. Campinas SP [s.n.].
9. SELMA OLIVEIRA MAIA BIBLIOTECÁRIO CRB M (2021) REVISTA DESENVOLVIMENTO INTELECTUAL No 07. Mensal Revista Desenvolvimento Intelectual 7(7).
10. PRETI F, CAPOBIANCO V, SANGALLI P (2022) Soil and Water Bioengineering (SWB) is and has always been a nature-based solution (NBS): A reasoned comparison of terms and definitions. Ecological Engineering 181: 106687.
11. Tertis M, et al. (2023) Biosensors: Receptor, Binding Protein, and Peptide Sensors. In: NARAYAN, R (Edt.)., Encyclopedia of Sensors and Biosensors (1st Edn.)., Oxford Elsevier, pp. 377-392.
12. HAMILTON C (2019) The Anthropocene. Encyclopedia of Ecology, pp. 239-246.
13. ALKAN H, MUKHERJEE S, KÖGLER F (2023) Chapter 8 - Microbial enhanced oil recovery. In: WANG Q (Edt.)., Recovery Improvement. Oil and Gas Chemistry Management Series. [s.l.] Gulf Professional Publishing, pp. 427-531.
14. ELIAS SA (2018) Paleoclimatology. Encyclopedia of the Anthropocene 1(5): 265-275.
15. MANÇANO SMCN, CAMPANA EH, PICÃO RC (2022) A broad perspective on antimicrobial resistance in coastal waters. Emerging Contaminants in the Environment Challenges and Sustainable Practices, pp. 183-201.
16. DUSSAUZE M, LE FLOCH S, LELCHAT F (2018) Extreme Environments: The New Exploration/Production Oil Area Problem. Oil Spill Studies: Healing the Ocean, Biomarking and the Law, pp. 83-121.
17. PONTE F, Luziane Luz, Débora Santos, Izabele Pontes (2022) Análise de risco geomorfológico na bacia do Rio Parauapebas, Região de Integração de Carajás (PA). Conjecturas 22(8): 201-221.
18. MANCINI S, Elena Egidio, Domenico Antonio De Luca, Manuela Lasagna (2022) Application and comparison of different statistical methods for the analysis of groundwater levels over time: Response to rainfall and resource evolution in the Piedmont Plain (NW Italy). Science of The Total Environment 846: 157479.
19. ETUK M, Stefano Viaroli, Igwe Ogbonnaya, Vivana Re (2022) Vulnerability mapping as a tool to foster groundwater protection in areas subject to rapid population expansion: The case study of Abuja Federal Capital Territory (Nigeria). Journal of Hydrology Regional Studies 42: 101158.
20. HUNOOR A, Snehal Patil, Paul L Edmiston, Umit S Ozkan (2022) Animated organic-inorganic hybrid materials and their use as catalyst scaffolds. Catalysis Today.
21. PRAKASH O, Shilpi Maurya, Purusottam Tripathy, Abhishek Sharma, Ritesh Vijay, et al. (2023) Chapter 21 - Nano- and phytoremediation technique for textile wastewater treatment and successive production of fertilizers. In: KUMAR V, et al. (Eds.)., Metagenomics to Bioremediation. Developments in Applied Microbiology and Biotechnology. [s.l.] Academic Press, pp. 537-559.
22. HUTSON M, MOSCOVITZ A (2019) Urban Health. Encyclopedia of Environmental Health, pp. 273-282.
23. ASADZADEH S, DE SOUZA FILHO CR (2017) Spectral remote sensing for onshore seepage characterization: A critical overview. Earth-Science Reviews 168: 48-72.
24. Sousa L R, et al. (2023) Sensing Materials: Paper Substrates. In: NARAYAN R (Edt.)., Encyclopedia of Sensors and Biosensors. (1st Edn.)., Oxford Elsevier, pp. 577-599.
25. Silva Gomes P, Monteiro Teles De Souza BH, Cerqueira De Paula C (2022) paisagismo do cerrado aplicado ao funcionamento da infraestrutura ecológica. Revista de Morfologia Urbana 10(2).
26. BASTOS L R, BELOTTI F M, LAURINDO E A (2021) Contaminação do solo e água subterrânea em áreas de disposição dos resíduos sólidos urbanos no estado de Minas Gerais. Revista Ibero-Americana de Ciências Ambientais 12(8): 259-273.
27. CRISTINA I (2021) OS IMPACTOS AMBIENTAIS CAUSADOS PELA ATIVIDADE MINERADORA. Angicos: [s.n.].
28. AURÉLIO F, SIMÕES M (2018) Arborização urbana-sua importância e benefícios para a qualidade socioambiental das cidades: Projeto "Uma Nova Vida, Matão + verde". Monografia—Fortaleza: Universidade Cidade de São Paulo.
29. PROPAGADORA ESDEVA A, FAGUNDES PAIVA D, HELENA SANTOS PREZOTO H (2021) CICLO DAS CHUVAS: uma reflexão sobre o tema.
30. Ventapane A L DE S, Santos P ML DOS (2021) Aplicação de princípios de Química Verde em experimentos didáticos: um reagente de baixo custo e ambientalmente seguro para detecção de íons ferro em água. Química Nova na Escola 43(2): 201-205.
31. JEFFERSON DA SILVA SANTOS R, ALBERTO RIBEIRO MENDONÇA L, JOSÉ ARAÚJO DA SILVA F (2021) GEOQUÍMICA DAS ÁGUAS SUBTERRÂNEAS DA BACIA SEDIMENTAR DO CARIRI CEARENSE, NORDESTE DO BRASIL. Início 40(4).
32. HARMON B, Lauren H Logan, Christopher E Spiese, Ryan Rahrig (2022) Flow alterations in rivers due to unconventional oil and gas development in the Ohio River basin. Science of The Total Environment 856(2): 159126.
33. CONAMA (2008) 308 RESOLUÇÕES DO CONAMA 308 RESOLUÇÕES DO CONAMA RESOLUÇÃO CONAMA no 396 de 2008 QUALIDADE DA ÁGUA. Brasília: [s.n.].
34. BRASIL (2013) MINISTÉRIO DO MEIO AMBIENTE CONSELHO NACIONAL DE RECURSOS HÍDRICOS RESOLUÇÃO. Brasília 153(17)
35. Yu C, Eva Högfors Rönnholm, Pekka Stén, Sten Engblom, Mats E Åström, et al. (2022) Iron sulfur geochemistry and acidity retention in hydrologically active macropores of boreal acid sulfate soils: Effects of mitigation suspensions of fine-grained calcite and peat. Science of The Total Environment 856: 159142.
36. VILA L, et al. (2021) Avaliações de Funções de Pedotransferência para Solos Brasileiros Evaluations of Pedotransfer Functions for Brazilian SoilsRevista Brasileira de Geografia Física.
37. SANTHIYASRI S, S Ivo Romauld, P Vivek, S Thiruvengadam (2023) Chapter 30 - Proteomics monitoring of microbes in contaminated environments. In: KUMAR V, et al. (Edt.)., Metagenomics to Bioremediation. Developments in Applied Microbiology and Biotechnology. [s.l.] Academic Press, pp. 723-735.
38. Xin X, Huang G, Zhang B (2021) Review of aquatic toxicity of pharmaceuticals and personal care products to algae. Journal of Hazardous Materials 410: 124619.

39. NAYEEM A, ALI MF, SHARIFFUDDIN JH (2022) The recent development of inverse vulcanized polysulfide as an alternative adsorbent for heavy metal removal in wastewater. Environmental Research 216(1): 114306.

40. FU B, Chenyang Yu, Jing Sun, Hongtao Wang, Yasuhisa Adachi (2022) The influence of humic substances on environmental behavior of antibiotic resistance genes: A mini-review. Journal of Hazardous Materials Advances 8: 100173.

41. BRITTO M, BAPTISTA GM, DE M, LIMA EA DE (2019) O estudo dos componentes do ciclo hidrológico desde métodos tradicionais até o uso de sensoriamento remoto: uma revisão. Paranoá cadernos de arquitetura e urbanismo 12(23): 127-146.

42. LIU L, Gregory L Schuster, Hans Moosmüller, Snorre Stamnes, Brian Cairns, et al. (2022a) Optical properties of morphologically complex black carbon aerosols: Effects of coatings. Journal of Quantitative Spectroscopy and Radiative Transfer 281: 108080.

43. LIU Y, Li Xin Shao, Wen Jing Yu, Jia Bao, Ting Yu Li, et al. (2022b) Simultaneous removal of multiple PFAS from contaminated groundwater around a fluorochemical facility by the periodically reversing electrocoagulation technique. Chemosphere 307: 135874.

44. RICHA A, TOUIL S, FIZIR M (2022) Recent advances in the source identification and remediation techniques of nitrate contaminated groundwater: A review. Journal of Environmental Management 316: 115265.

45. CASTRO SANTOS T, Elsa Goeriga, Pingguo He, George V Lauder (2022) Applied aspects of locomotion and biomechanics. Em Fish Physiology [s.l.] Academic Press 39: 1-50.

46. Tiwari S, Yadav D, Sarangi B K (2023) Chapter 24 - Bioaugmentation of metal phytoremediation through plant-microbe interaction. In: KUMAR V, et al. (Eds.)., Metagenomics to Bioremediation. Developments in Applied Microbiology and Biotechnology. [s.l.] Academic Press, pp. 595-616.

47. HYPOLITO R, SUMI E (2021) REMEDIAÇÃO ELETROCINÉTICA-NOVAS TÉCNICAS. ELECTROKINETIC REMEDIATION-NEW TECHNIQUES 40(3).

48. Zhou J, Lei Ding, Mu Shi, Ralph EF Lindeboom, Changzheng Cui (2022) The key factor in High Pressure Hydrogenotrophic Denitrification: Hydrogen partial pressure. Journal of Water Process Engineering 49: 103195.

49. Tedesco A M Oliveira GA, Trojan F (2021) Assessment of the vulnerability to groundwater contamination by ahp and topsis methods. Engenharia Sanitaria e Ambiental 26(3): 401-407.

50. Yan J, Guang Li, Guangping Qi, Xiangdong Yao, Miao Song (2022) Improved feed forward with bald eagle search for conjunctive water management in deficit region. Chemosphere 309(Pt 2): 136614.

51. CHEN J, Hao Wu, Hui Qian, Xinyan Li (2018) Challenges and prospects of sustainable groundwater management in an agricultural plain along the Silk Road Economic Belt, north-west China. International Journal of Water Resources Development 34(3): 354-368.

52. Tundisi JG, Tundisi TM (2016) Integrating ecohydrology, water management, and watershed economy: Case studies from Brazil. Ecohydrology and Hydrobiology Elsevier 16(2): 83-91.

53. COOPERMAN A, MCLARTY AR, SEIM B (2022) Drivers of successful common-pool resource management: A conjoint experiment on groundwater management in Brazil. Global Environmental Change 74: 102512.

54. LI M, Xiaohua Yang, Feifei Wu, Pius Babuna (2022) Spatial equilibrium-based multi-objective optimal allocation of regional water resources. Journal of Hydrology: Regional Studies 44: 101219.

55. RIBAS PPSO DOS, CCCGLS (2021) Estudos sobre remoção de micropoluentes emergentes em efluentes no Brasil. Revista Brasileira de Meio Ambiente 9: 165-171.

56. BAO Q, Jun Dong, Zhen Dong, Miao Yang (2022) A review on ionizing radiation-based technologies for the remediation of contaminated groundwaters and soils. Chemical Engineering Journal 446: 136964.

57. KUMAR A, Vivek Raj, Abhinav, Mohammad Ali, Ashok Ghosh, et al. (2022) Chapter 6 - Autophagy in arsenic exposed population and cancer patients. In: KUMAR D, ASTHANA S (Edt.)., Autophagy and Metabolism. [s.l.] Academic Press, pp. 141-161.

58. MISHEL PF, PF Steffi, B Thirumalaiyammal, Rajeswari Anburaj (2023) Chapter 1 - Bioremediation: A green technology for environmental cleanup. In: KUMAR V, et al. (Eds.)., Metagenomics to Bioremediation. Developments in Applied Microbiology and Biotechnology. [s.l.] Academic Press, p. 3-21.

59. BAO Q, Lujun Chen, Jinping Tian, Jianlong Wang (2014) Degradation of 2-mercaptobenzothiazole in aqueous solution by gamma irradiation. Radiation Physics and Chemistry 103: 198-202.

60. KANG LL, Ya Nan Zeng, Yi Tong Wang, Jun-Guo Li, Fu Ping Wang, et al. (2022) Removal of pollutants from wastewater using coffee waste as adsorbent: A review. Journal of Water Process Engineering 49: 103178.

61. Zhu J, Lishan Zhang, Junyong Liu, Shan Zhong, Pin Gao, et al. (2022) Trichloroethylene remediation using zero-valent iron with kaolin clay, activated carbon and bacteria. Water Research 226: 119186.

62. PACCHECO JOÃO LUIS DE OLIVEIRA, SABINO IVAN KELLERMANN, WESTIN NPO (2020) Efeito Fotoelétrico. 4(176000): 1-11.

63. BERTAGI LT, BASILIO AO, PERALTA ZAMORA P (2021) Environmental applications of persulfate: Remediation of contaminated groundwater and soils. Quimica NovaSociedade Brasileira de Quimica.

64. Wang T, Kun Miao Xu, Kai-Xin Yan, Li Guang Wu, Kou Ping Chen, et al. (2022) Comparative study of the performance of controlled release materials containing mesoporous MnOx in catalytic persulfate activation for the remediation of tetracycline contaminated groundwater. Science of The Total Environment, pp. 157217.

65. Yuan M, Xiaohui Wang, Fang Zhao, Litao Wang, Meng Liu (2022) Coupling microscale zero-valent iron and autotrophic hydrogen-bacteria provides a sustainable remediation solution for trichloroethylene-contaminated groundwater: Mechanisms, regulation, and engineering implications. Water Research 216: 118286.

66. HAN P, Jiayin Xie, Xueming Qin, Xinru Yang, Yongsheng Zhao (2022) Experimental study on in situ remediation of Cr(VI) contaminated groundwater by sulfidated micron zero valent iron stabilized with xanthan gum. Science of The Total Environment 828: 154422.

67. SCHERER L, RUEDA O, SMETANA S (2023) Chapter 14 - Environmental impacts of meat and meat replacements. In: MEISELMAN HL, MANUEL LORENZO J (Eds.)., Meat and Meat Replacements. [s.l.] Woodhead Publishing, pp. 365-397.

68. PANDEY K, SHARMA S, SAHA S (2022) Advances in design and synthesis of stabilized zero-valent iron nanoparticles for groundwater remediation. Journal of Environmental Chemical Engineering 10(3): 107993.

69. Tian H, Ying Liang, Tianle Zhu, Xiaolan Zeng, Yifei Sun, et al. (2018) Surfactant-enhanced PEG-4000-NZVI for remediating trichloroethylene-contaminated soil. Chemosphere 195: 585-593.

70. IKHLAYEL M (2016) Differences of methods to estimate generation of waste electrical and electronic equipment for developing countries: Jordan as a case study. Resources Conservation and Recycling 108: 134-139.

71. KATARIA N, Divya Bhushan, Renuka Gupta, Saravanan Rajendran, Michelle Yee Mun Teo, et al. (2022) Current progress in treatment technologies for plastic waste (bisphenol A) in aquatic environment: Occurrence, toxicity and remediation mechanisms. Environmental Pollution 315: 120319.

72. MARGRET AA, S Aishwarya, A Arun, R Jasmine (2023) Chapter 7 - Interface of 'meta-omics' in gut biome remediation to unravel the complications of environmental pollutants. In: KUMAR V, et al. (Eds.)., Metagenomics to Bioremediation. Developments in Applied Microbiology and Biotechnology. [s.l.] Academic Press, pp. 183-206.
73. MOFRADNIA SR, Reihaneh Ashouri, Zahra Tavakoli, Fereshteh Shahmoradi, Hamid Rashedi, et al. (2019) Effect of zero-valent iron/starch nanoparticle on nitrate removal using MD simulation. International Journal of Biological Macromolecules 121: 727-733.
74. MOUSSA DT, Muftah H El Naas, Mustafa Nasser, Mohammed J Al Marri (2017) A comprehensive review of electrocoagulation for water treatment: Potentials and challenges. Journal of Environmental ManagementAcademic Press 186(1): 24-41.
75. Xin J, Yuan Wang, Zeliang Shen, Yang Liu, Haotong Wang, et al. (2021) Critical review of measures and decision support tools for groundwater nitrate management: A surface-to-groundwater profile perspective. Journal of Hydrology 598: 126386.
76. LIU Y, ET AI (2020) Corncob PRB para remoção de nitrato no local em águas subterrânea. Arabian Journal of Geosciences 13: 1-11.
77. Zhang W, Shan Nan, Bai Ying, Yin Lin (2020) The innovative application of agriculture straw in situ field permeable reactive barrier for remediating nitrate-contaminated groundwater in grain-production areas. Biochemical Engineering Journal 164: 107755.
78. BENEKOS A K, Foteini E Tziora, Athanasia G Tekerlekopoulou, Stavros Pavlou, Yan Qun, et al. (2021) Nitrate removal from groundwater using a batch and continuous flow hybrid Fe-electrocoagulation and electrooxidation system. Journal of Environmental Management 297: 113387.
79. FAISAL AAH, SULAYMON AH, KHALIEFA QM (2018) A review of permeable reactive barrier as passive sustainable technology for groundwater remediation. International Journal of Environmental Science and Technology 15(5): 1123-1138.
80. HAN K, Rui Zuo, Pengcheng Ni, Zhenkun Xue, Donghui Xu, et al. (2020) Application of a genetic algorithm to groundwater pollution source identification. Journal of Hydrology 589: 125343.
81. Sima M W, Jaffé PRA (2021a) critical review of modeling Poly- and Perfluoroalkyl Substances (PFAS) in the soil-water environment. Science of The Total Environment 757: 143793.
82. Sima M W, Jaffé PRA (2021b) critical review of modeling Poly- and Perfluoroalkyl Substances (PFAS) in the soil-water environment. Science of The Total Environment 757: 143793.
83. Wang X, Christoph Müller, Joshua Elliot, Nathaniel D Mueller, Philippe Ciais, et al. (2021) Global irrigation contribution to wheat and maize yield. Nature Communications 12(1): 1235.
84. KOZLOVA M, OVERLAND I (2022) Combining capacity mechanisms and renewable energy support: A review of the international experience. Renewable and Sustainable Energy Reviews 155: 111878.
85. MA B, Tianming Huang, Jie Li, Zhenbin Li, Yin Long, et al. (2021) Tracing nitrate source and transformation in a semiarid loess aquifer with the thick unsaturated zone. CATENA 198: 105045.
86. AJALA OJ, JO Tijani, RB Salau, A S Abdulkareem, OS Aremu, et al. (2022) A review of emerging micro-pollutants in hospital wastewater: Environmental fate and remediation options. Results in Engineering, pp. 100671.
87. MUKHERJEE A, Emilio D'Ugo, Roberto Giuseppetti, Fabio Magurano, Paul D Cotter (2023) Chapter 5 - Metagenomic approaches for understanding microbial communities in contaminated environments: Bioinformatic tools, case studies and future outlook. In: KUMAR V, et al. (Eds.)., Metagenomics to Bioremediation. Developments in Applied Microbiology and Biotechnology. [s.l.] Academic Press, pp. 103-156.
88. RAN Q, Dong Ren, Yongjun Wang, Min Tong, Yuanhui Sun, et al. (2019) Volcanic Rocks Architecture and Sequence. Development of Volcanic Gas Reservoirs, pp. 23-113.
89. KODA E, Jan Winkler, Paweł Wowkonowicz, Martin Černý, Agnieszka Kiersnowska, et al. (2022) Vegetation changes as indicators of landfill leachate seepage locations: Case study. Ecological Engineering 174: 106448.
90. BEBINA DEVI T, SHARMA A, KUMAR B (2019) Flow characteristics in a partly vegetated channel with emergent vegetation and seepage. Ecohydrology & Hydrobiology 19(1): 93-108.
91. Volchek A, Kirvel I, Sheshko N (2019) Environmental flow assessment for the Yaselda River in its Selets reservoir section. Ecohydrology & Hydrobiology 19(1): 109-118.
92. BALARAM V, RANI A, RATHORE DPS (2022) Uranium in groundwater in parts of India and world: A comprehensive review of sources, impact to the environment and human health, analytical techniques, and mitigation technologies. Geosystems and Geoenvironment 1(2): 100043.
93. FORO ECONÓMICO MUNDIAL, et al. (2021) The global risks report 2021 insight report. [s.l.] World Economic Forum.
94. OLIVEIRA RPCA DE, BCSM, FNC DE A, MALOC DE (2021) INFLUÊNCIA DO PLANTIO DE ÁRVORES EM CEMITÉRIOS: VANTAGENS E POSSIBILIDADES DE ATENUAÇÃO DE IMPACTOS AMBIENTAIS NEGATIVOS ADVINDOS DE SEPULTAMENTOS. Revista Multidisciplinar De Educação E Meio Ambiente 2(2): 67.
95. SANTOS HG DOS, EMBRAPA SOLOS (2006) Sistema brasileiro de classificação de solos. Rio de Janeiro.
96. Silva M I, AML Gonçalves, WA Lopes, MTV Lima, CTF Costa, et al. (2021) Assessment of groundwater quality in a Brazilian semiarid basin using an integration of GIS, water quality index and multivariate statistical techniques. Journal of Hydrology 598: 126346.
97. Yaashikaa PR, Ponnusamy Senthil Kumar, Tran Cam Nhung, RV Hemavathy d, Marie Jyotsna Jawahar, et al. (2022) A review on landfill system for municipal solid wastes: Insight into leachate, gas emissions, environmental and economic analysis. Chemosphere 309: 136627.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2024.55.008681

Marcos Fernandes de Oliveira. Biomed J Sci & Tech Res