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REMINERALIZERS IN THE BRAZILIAN AGRICULTURAL CONTEXT

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Abstract: The high productivity of conventional agriculture is temporary, as it compromises future productivity due to its intensive soil use methods, in addition to the dependence on imported inputs that make up the formulations of soluble fertilizers, such as NPK. It is crucial to strengthen agricultural practices aimed at productivity and environmental conservation, employing the use of inputs and fertilizers in a sustainable manner. This work proposes a systematization of the concepts pertinent to the context of agrogeology and soil remineralization. Soil remineralization is a process that involves the replacement of plant nutrients in the soil using fine minerals with the aim of restoring soil fertility. They are divided into macronutrients, essential for plant metabolism and development (P, K, S, Ca and Mg) and micronutrients: beneficial (Na, Co, Si, Ni, Se and V) and essential (B, Cl, Cu, Fe, Mg, Mo and Zn). Normative Instruction, number: 5, of March 10, 2016, in its Article 4, sets out the criteria for specifications and guarantees that remineralizers must present for registration purposes with the Ministry of Agriculture, Livestock and Food Supply (M.A.P.A), in order to ensure efficiency and effectiveness in replacing NPK in agricultural crops.

Keywords: Rocking; Rock Powder; Agroecology.

INTRODUCTION

Modern agricultural techniques, which include extensive production, monoculture and the expansion of cultivated areas, are contributing to the decline in soil quality and fertility, which in turn results in the need for nutrient replenishment through chemical fertilizers. Conventional fertilizers, composed mainly of nitrogen, phosphorus and potassium (NPK), provide agricultural crops with macro and micronutrients through concentrated and soluble compounds (Bergmann; Theodoro; Hoff, 2011). The increase in the consumption of these fertilizers is driven by population growth, which increases the need for food and, in turn, increases the expansion of areas designated for agriculture (Zhang; Zhang, 2007).

According to data from the Food and Agriculture Organization of the United Nations (UN/FAO, 2019), in 2016 the production of NPK fertilizers reached approximately 214 million tons. Additionally, the report by the International Fertilizer Association (IFA, 2018) revealed that in a 50-year period, from 1965 to 2015, global fertilizer production increased significantly, registering a growth of 342.05%. However, the continuous and indiscriminate use of NPK in the soil generates losses of these nutrients due to leaching of rainwater, leading to contamination of water resources and phosphorus fixation. These processes, in the long term, make the soil unavailable for subsequent crop cycles (Bergmann; Theodoro; Hoff, 2011).

Therefore, conventional Brazilian agriculture, in addition to promoting intensive soil use in an environmentally unsustainable manner, presents another weakness: the dependence on imported inputs that make up the formulations of soluble fertilizers, such as NPK. By knowing the economic, social, and environmental implications of NPK use, it has become imperative to explore alternatives to maintain soil fertility and quality while considering the balance of the soil-plant system. In this context, it is essential to establish comprehensive policies for food and fertilizer production, while promoting investments in research and development of technologies that combat soil fertility loss (Tenkorang, Lowenberg-Deboer, 2008). In addition, it is crucial to strengthen agricultural practices aimed at productivity and environmental conservation, employing the use of inputs and fertilizers in a sustainable manner.

In this perspective, a debate has emerged around remineralizers in agriculture, aiming at providing essential nutrients for soil fertility. In addition, this approach includes other benefits such as increasing the soil's carbon retention capacity, improving cation exchange capacity (CEC), and expanding water retention capacity (WRC); (Moraes, 2021). In Brazilian soils, the application of remineralizers is a low-cost strategy, viable for both family farming and large-scale agricultural operations. It is noteworthy that remineralizers represent a supplementary approach to traditional fertilizers, playing a crucial role in promoting sustainable agricultural systems. Additionally, this practice contributes substantially to reducing the need for fertilizer imports (Moraes, 2021).

This work proposes a systematization of concepts relevant to the context of agrogeology and soil remineralization, providing a comprehensive view of the application and potential sources of soil fertility and quality in the agricultural scenario. The main focus will be directed to the Brazilian agricultural context, where we seek to understand the progress and trends related to the use of remineralizers as a strategy for soil fertility and conservation, highlighting the benefits, challenges and perspectives of these practices.

REMINERALIZERS, ROCK POWDER AND ROCKING: MAIN CONCEPTS

Soil remineralization is a process that involves replenishing plant nutrients in the soil using fine minerals. The goal is to restore soil fertility, which may have been depleted by anthropogenic and/or natural factors, such as extensive agricultural activities and leaching, for example (Bergmann; Theodoro; Hoff, 2011).

According to Normative Instruction Number: 5 of March 10, 2016, in its Article 2, Remineralizers are defined according to their water retention capacity (WRC), their cation exchange capacity (CE), their electrical conductivity (EC), their density, their Hydrogen potential (pH), the sum of their bases (sum of the contents of $CaO+MgO+K_2O$ or by the sum of the contents of $CaO+K_2O$ or by the sum of the contents of $MgO+K_2O$) and its maximum humidity.

In its article 3, substrates can be classified according to the origin and type of raw materials used in their manufacture (Classes A to F):

> Class "A": product that uses, in its production, raw materials of vegetable or animal origin or from agro-industrial processing exempt from sanitary waste, where toxic heavy metals, potentially toxic elements or compounds are not used in the process, resulting in a product that is safe to use in agriculture;
>
> Class "B": product that uses, in its production, raw materials from industrial or agro-industrial processing exempt from sanitary waste, where toxic heavy metals, potentially toxic elements or compounds are used in the process, resulting in a product that is safe to use in agriculture;
>
> Class "C": product that uses, in its production, any quantity of raw materials from household waste exempt from sanitary waste or potentially toxic materials, resulting in a product that is safe to use in agriculture;
>
> Class "D": product that uses, in its production, any quantity of raw material from the treatment of sanitary and industrial waste, resulting in a product that is safe to use in agriculture;

Class “E”: product that uses, in its production, exclusively raw material of mineral or synthetic origin, resulting in a product that is safe to use in agriculture; and

Class “F”: product that uses, in its production, in any proportion, a mixture of raw materials from products in Classes “A” and “E”, respectively.

The use of these geological materials is part of the assumptions of rock technology and, indirectly, facilitates the achievement of sustainable development objectives related to soil management, climate change and the preservation of water resources.

Rocking is a technique that involves the addition of rock powder (or remineralizer) or ground rocks to the soil which, combined with weathering, promotes the slow release of mineral elements from its composition in the soil. These elements are absorbed by plant roots and promote the correction of acidic soils, especially for agroecological crops (Theodoro; Almeida, 2013). Rock Powder is a type of input used in the agricultural fertilization process and can present different granulometries of crushed rocks.

AGROECOLOGY AND AGROGEOLOGY: FUNDAMENTALS FOR SUSTAINABLE AGRICULTURE

Humanity is currently going through a period of ecological transition, which requires a reassessment of concepts and, certainly, changes in procedures and techniques, especially in agriculture. In this sense, it is extremely important that the production system be based on the concepts and practices of agroecology, based on environmental rationality, which promotes increasingly sustainable practical actions (LEFF, 2002). With this, agroecology presents sustainable models that provide the basic ecological principles for production systems.

Agroecology emerges as a central and fundamental approach in the search for sustainable agriculture, representing a transformation in the way of practicing and conceiving agriculture, with a focus on sustainability and economic and social development. The adoption of a technological and organizational standard is proposed in order to use natural resources rationally, aiming at agricultural results that integrate agronomic, ecological and socioeconomic principles (Altieri, 2004). This is an approach that integrates agronomic, ecological and socioeconomic principles to understand and evaluate the effect of technologies on agricultural systems and society.

Sustainable production in agroecology arises from the harmonious balance between several factors, such as plants, soils, nutrients, sunlight, moisture and other interdependent organisms (Altieri, 2004). Geodiversity encompasses a variety of characteristics, including rock formations, minerals, fossils, geomorphological characteristics and pedological properties (Gray, 2004). While agroecology is recognized as an interdisciplinary field of knowledge, a vital connection with agrogeology is established, addressing the intrinsic relationships between geology, soils and the complex sociobiodiversity of ecosystems.

Agrogeology, as discussed by Jones, Guinel, and Antunes (2020), represents the exploration of geology for use in agriculture, with an emphasis on the use of rocks present in regions close to cultivated areas, as they have the potential to increase fertility and provide nutrients to plants. This approach aims to promote sustainable, low-carbon agriculture. Rocha Neto (2022) expands on this analysis by relating agrogeology to the formulation of effective public policies, considering it as a solution to issues related to hunger and climate change. On the other hand, Lais, Batista, and Stoffel (2022) highlight agrogeology as a set of knowledge that connects conventional agriculture to organic agriculture, with regard to nutritional supplementation, with a focus on not using petroleum-derived compounds in their formulations. An additional concept used is that of "agrominerals", which are mineral substances of relevance to agriculture and can be used to perform functions both as soil correctives and as sources of nutrients for plants in an efficient and safe manner (for example: limestone, phosphates, remineralizers) and which are registered with the Ministry of Agriculture, Livestock and Food Supply (M.A.P.A.); (Martinazzo et al., 2022).

These perspectives converge on a central premise: the ecosystem acts as a driver for geological reorganization, a process that can occur naturally over long periods or be accelerated through scientific knowledge of the chemical potentials present. A crucial aspect of the application of agrogeology lies in understanding the ions of the elements in rocks, as well as their chemical interactions and the energy released by the process, which is capable of providing essential nutrients to plants. The solubilization of these components is essential to prevent them from acting as blockers in the soil, allowing them to function as electronic acceptors and thus provide adequate physical and chemical conditions for the development of mesofauna and the formation of new individuals.

In this scenario, understanding soil formation becomes highly relevant, along with understanding the dependence of phosphorus in food production (Cordell; Drangert; White, 2009), the preservation of organic matter associated with minerals in the soil (Morra et al., 2023) and the adoption of management practices that sustain bacterial communities (Martins et al., 2023). These elements combined form essential characteristics to be observed, maintained and, in many cases, reconstituted in the context of agriculture.

By incorporating agrogeology, agroecology gains a solid foundation to guide soil and mineral input management practices that optimize agricultural productivity, environmental preservation and the resilience of agricultural systems.

RELEVANT FACTORS FOR THE USE OF REMINERALISERS

The main remineralizers can be classified into macronutrients that are essential for plant metabolism and development, which are absorbed in greater quantities (P, K, S, Ca and Mg) and micronutrients, which are subdivided into beneficial (Na, Co, Si, Ni, Se and V) and essential (B, Cl, Cu, Fe, Mg, Mo and Zn). In addition to nutrients, soil conditioners can also improve the agricultural capacity of the soil, such as: pH correction, structural corrections (aeration and drainage) and protection conditions (coverage techniques).

The availability of nutrients in ground rocks is considered low and insufficient to meet the demand of crops for obtaining high productivity. To overcome this limitation, the development of strategies to improve the availability of nutrients present in rock powder is necessary, in order to consolidate its use as an alternative source to conventional fertilizers.

In Brazil, the main remineralizers used come from basalt, schist, kamafugites, phonolites, gneisses and serpentinites. Among these rocks, it is worth highlighting the phonolite (volcanic origin, composed of about 9% K2O) and the basalt rocks that are abundant in the territory (Theodoro et al., 2021).

THE USE OF REMINERALIZERS IN BRAZIL AND POTENTIAL BENEFITS

In the 20th century, the concepts of agriculture were changed, aiming at the conceptual changes advocated by the logic of the industrial revolution. Combined with these new concepts and the increase in population, according to Quirino (2021), a space arose to argue that the success of agricultural production in quantity and quality would be in the use of agricultural inputs considered capable of supplying these attributes.

Throughout the 20th century, agriculture in Brazil and around the world developed technological packages, which included improved seeds, synthetic fertilizers, pesticides, among others, whose results presented as a good response for a given production system, but did not favor organic production systems (Vidal et al., 2021), disregarding socioeconomic and environmental sustainability.

The inputs used in extensive production systems, in general, are considered to have a very high impact, from the perspective of environmental preservation and human health. According to Pignati et al. (2017), in a survey on the consumption of herbicides, fungicides and insecticides carried out between 2012 and 2016, products were used whose active ingredients were classified as 15% extremely toxic, 25% highly toxic, 35% moderately toxic and 25% slightly toxic, in the classification for humans.

The use of bio-inputs, remineralizers and rock powders arose from the consequences generated by the use of these inputs. In various parts of the world, movements have emerged to question this development model, which, according to Gomes (2011), involves a holistic change in the entire production system, contained in the epistemological bases of agroecology.

It is essential that Brazil, a country of continental dimensions and a world reference in agricultural and livestock production, has appropriate and sufficient inputs in all its regions, in order to guarantee sustainability for the various production systems, which is not a reality.

In historical continuity, on December 23, 2003, Law 10.831, which provides for organic agriculture, was sanctioned by the then President of the Republic. Article 9 of the aforementioned law establishes that "inputs with regulated use for organic agriculture must be subject to a differentiated registration process, which ensures the simplification and agility of their regularization" (Brazil, 2003). The aforementioned article already expressed the desire to change the reality faced, at the time, in relation to what was offered in the agricultural inputs market throughout the country.

On July 23, 2009, Decree, number: 6,913, exposed the phytosanitary products with approved use for organic agriculture, exempting interested parties from presenting agronomic, toxicological and environmental studies as long as the criteria established by law were met, which previously represented obstacles to their adoption. This decree established the reference specifications, established based on information, tests and agronomic, toxicological and environmental studies carried out by public or private educational, technical assistance and research institutions", in a procedure coordinated by M.A.P.A. (Brazil, 2009).

Thus, according to Vidal et al. (2021), the use of technologies associated with bioinputs is a reality in Brazil. In addition to the clear need for the organic sector, there is a large-scale use by conventional agriculture and livestock. In order to encourage and consolidate the movement for the implementation of bioinputs in Brazil, on

May 26, 2020, M.A.P.A. released the National Bioinputs Program, through Federal Decree, number: 10,375. According to Vidal et al. (2021), the aforementioned Decree arises with the concern to regulate the technology, with due legal and scientific security, embodied in the specific legal framework, as an unwavering concern to pursue the precautionary principle. Thus, in Brazil, organic production systems must follow some Normative Instructions established by M.A.P.A, which contain products and processes permitted for use in organic production.

Specifically, in the State of Goiás and, for the first time in Brazil, the Government published, in the State Official Gazette (D.O.E.) of May 17, 2021, Law Number: 21,005, of May 14, 2021, which institutes the State Bioinputs Program.

The objective of the Program, proposed by the State Secretariat of Agriculture, Livestock and Supply (Seapa), is to expand and strengthen the adoption of practices for the evolution of the agricultural sector, with the expansion of production, development and use of bioinputs and sustainable production systems. Law 12,890 of December 10, 2013 (Brazil, 2013), defines in its article 3, remineralizer as any material of mineral origin that has undergone only reduction and classification of size by mechanical processes and that alters soil fertility rates through the addition of macro and micronutrients for plants, as well as promotes the improvement of physical or physicochemical properties or biological activity of the soil.

As a complement to Law 12,890 (Brazil, 2013), Normative Instruction Number: 5 of March 10, 2016 (M.A.P.A., 2016), in its article 4, sets out the criteria for specifications and guarantees that remineralizers must present for registration with the Ministry of Agriculture, Livestock and Food Supply (M.A.P.A.). The specifications are as follows:

1) Perform the physical granulometric characterization of the rock powder. For remineralizers in powder form, the fraction that passes through the ABNT sieve Number: 50 (with an orifice diameter of 0.30 mm) has a theoretical reactivity equal to 100%, considering a period of 12 to 36 months; particles with a diameter between 0.30 and 0.84 mm (pass through the ABNT sieve Number: 20, but are retained in the ABNT sieve, number: 50) have a reactivity of 60%, in the same period; the coarser particles, with a diameter between 0.84 and 2.00 mm (are retained in the ABNT sieve number: 20, but pass through the ABNT sieve Number: 10) have a reactivity equal to 20% and, finally, particles with a diameter greater than 2.00 mm have no effect in this period of time.

2) The sum of the bases relating to the physical-chemical analyses performed on the rock powder (remineralizer) must be equal to or greater than 9%. 3) The potassium oxide content must be equal to or greater than 1% (weight/weight)

4) The percentage of free silica (quartz) must be less than 25%.

5) It also states that the maximum contaminant limits must be the following: Arsenic must be less than 15 ppm; Cadmium must be less than 10 ppm; Mercury must be less than 0.1 ppm and Lead, less than 200 ppm.

6) Proof of agronomic efficiency must be carried out by means of experimental protocols.

To be accepted as a remineralizer, the product must present the minimum configurations of the macronutrient phosphorus and micronutrients (Table 1).

Nutrient	Minimum total content (% by weight/weight)
Phosphorus (P_2O_5)	1
Boron (B)	0,03
Chlorine (Cl)	0,1
Cobalt (Co)	0,005
Copper (Cu)	0,05
Iron (Fe)	0,1
Manganese (Mn)	0,1
Molybdenum (Mo)	0,005
Nickel (Ni)	0,005
Selenium (Se)	0,03
Silicon (Si)	0,05
Zinc (Zn)	0,1

Table 1: Minimum phosphorus and micronutrient levels declared in Remineralizers.

Source: (M.A.P.A., 2016)

FINAL CONSIDERATIONS

Considering the good performance that the use of remineralizers has shown, when compared to soluble NPK, in agricultural crops, it becomes relevant to continue studies in order to develop planting strategies with reduced use of raw materials and the import of agricultural inputs.

REFERENCES

ALTIERI, Miguel A.; ANDERSON, M. Kat; MERRICK, Laura C. Peasant agriculture and the conservation of crop and wild plant resources. **Conservation Biology**, v. 1, n. 1, p. 49-58, 1987.

ALTIERI, Miguel A.; LETOURNEAU, Deborah K.; DAVIS, James R. Developing sustainable agroecosystems. **BioScience**, v. 33, n. 1, p. 45-49, 1983.

ALTIERI, Miguel. Agroecologia: a dinâmica produtiva da agricultura sustentável. 4. ed. Porto Alegre: Editora da Universidade/UFRGS, 2004.

BATISTA, Camila Lais Ramalho; STOFFEL, Janete. Agroecologia e produção orgânica: características que distinguem e/ou aproximam os sistemas de produção sustentáveis. Colóquio – **Revista do Desenvolvimento Regional**, v. 19, Edição Especial 1 (SOBER), p. 25-49, março, 2022.

BERGMANN, M.; THEODORO, S.; HOFF, R. Rochagem: uma alternativa sustentável na remineralização de solos. **Conselho em Revista**, Porto Alegre, v. 7, n. 85, p. 34-35, 2011.

BRASIL. Lei nº 12.890, de 10 de dezembro de 2013. Altera a Lei nº 6.894, de 16 de dezembro de 1980, para incluir os remineralizadores como uma categoria de insumo destinado à agricultura, e dá outras providências.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Decreto nº 6.913, de 23 de julho de 2009. Acresce dispositivos ao Decreto nº 4.074, de 4 de janeiro de 2002, que regulamenta a Lei nº 7.802, de 11 de julho de 1989, que dispõe sobre a pesquisa, a experimentação, a produção, a embalagem e rotulagem, o transporte, o armazenamento, a comercialização, a propaganda comercial, a utilização, a importação, a exportação, o destino final dos resíduos e embalagens, o registro, a classificação, o controle, a inspeção e a fiscalização de agrotóxicos, seus componentes e afins. Diário Oficial da União, 24 de julho de 2009.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Lei nº 10.831, de 23 de dezembro de 2003. Dispõe sobre a agricultura orgânica e dá outras providências. Diário Oficial da União, 24 de dezembro de 2003. Seção 1, p. 8-9.

CORDELL, Dana; DRANGERT, Jan-Olof; WHITE, Stuarticle The story of phosphorus: global food security and food for thought. **Global Environmental Change**, v. 19, n. 2, p. 292-305, 2009.

FAO – Organização das Nações Unidas para Alimentação e Agricultura. Base de dados da FAOSTAT. Fertilizantes por nutriente. 2019. Disponível em: http://FAO.fao.org/.

GOMES, João C.C. **As bases epistemológicas da Agroecologia**. In: CAPORAL, Francisco R.; AZEVEDO, Edisio O. (Org.). Princípios e perspectivas da agroecologia. Paraná, PR: IFPR, 2011, p. 13-42.

GRAY, Murray. **Geodiversity: valuing and conserving abiotic nature**. John Wiley & Sons, 2004.

IFA – Associação Internacional de Fertilizantes. Base de dados da IFASTAT. Produção, consumo, importação de exportação de fertilizantes. 2018. Disponível em: https://www.fertilizer.org/.

JONES, James MC; GUINEL, Frédérique C.; ANTUNES, Pedro M. Carbonatites as rock fertilizers: a review. **Rhizosphere**, v. 13, p. 100188, 2020.

LEFF, Enrique. Agroecologia e saber ambiental. **Agroecologia e desenvolvimento rural sustentável**, v. 3, n. 1, p. 36-51, 2002.

MAPA – Ministério da Agricultura, Pecuária e Abastecimento. Instrução Normativa nº 5, de 10 de março de 2016. Regras sobre definições, classificação, especificações e garantias, tolerâncias, registro, embalagem, rotulagem e propaganda dos remineralizadores e substratos para plantas, destinados à agricultura. Brasília, 2016. Disponível em: https://www.in.gov.br/materia/-/asset_publisher/Kujrw0TZC2Mb/content/id/21393137/do1-2016-03-14-instrucao-normativa-n-5-de-10-de-marco-de-2016-21393106.

MARTINS, Guilherme Lucio *et al*. The role of land use, management, and microbial diversity depletion on glyphosate biodegradation in tropical soils. **Environmental Research**, v. 231, p. 116178, 2023.

MORAES, Letícia Nunes de. **Uso de pó de rocha na agricultura brasileira**. 2021. 40 f. TCC (Graduação) - Curso de Faculdade de Agronomia e Medicina Veterinária, Universidade de Brasília, Brasília- DF, 2021.

MORRA, Brian *et al*. Vegetation productivity drives soil mineral associated organic matter formation and the relative contribution of sorption capacity across climates. **Rhizosphere**, v. 27, p. 100737, 2023.

ODUM, Howard T. Environment, power, and society. New York/London/Toronto: Wiley Interscience, 1971.

PIGNATI, Wanderlei Antonio *et al*. Distribuição espacial do uso de agrotóxicos no Brasil: uma ferramenta para a Vigilância em Saúde. **Ciência & Saúde Coletiva**, v. 22, p. 3281-3293, 2017.

QUIRINO, Mayara. Entre aplausos, vaias e terra**:** uma análise da construção do discurso polêmico em torno do uso de agrotóxicos no Brasil. 2021.

ROCHA NETO, João Mendes da. Tão perto e tão longe: trajetória da agroecologia na agenda brasileira de políticas públicas. **Saúde em Debate**, v. 46, n. spe2, p. 455-466, 2022.

SACHS, Ignacy. Caminhos para o desenvolvimento sustentável. Organização: Paula Yone Stroh. 3. ed. Rio de Janeiro: Garamond, 2008.

SILVEIRA, Carlos Augusto Posser *et al*. Protocolo para avaliação da eficiência agronômica de remineralizadores de solo – primeira versão. Pelotas: Embrapa Clima Temperado, 2019. 23 p.

TENKORANG, F., LOWENBERG-DEBOER, J. (2008). Forecasting long-term global fertilizer demand. **Nutrient Cycling in Agroecosystems**, *83*(3), 233.

THEODORO, S.H.; ALMEIDA, E. Agrominerais e a construção da soberania em insumos agrícolas no Brasil. Agriculturas, v. 10, n. 1, p. 22-28, 2013. Disponível em: http://aspta.org.br/files/2013/06/Agriculturas-V10N1.pdf Acesso em: 06 ago. 2023.

THEODORO, Suzi Huff *et al*. Rochas basálticas para rejuvenescer solos intemperizados. 2021.

VIDAL, Mariane Carvalho *et al*. Bioinsumos: a construção de um Programa Nacional pela Sustentabilidade do Agro Brasileiro. **Economic Analysis of Law Review**, v. 12, n. 3, p. 557-574, 2021.

ZHANG, WenJun; ZHANG, XiYan. A forecast analysis on fertilizers consumption worldwide. **Environmental Monitoring and Assessment**, v. 133, p. 427-434, 2007.