Biological Forum – An International Journal **14(3): 888-895(2022)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Pools and Fractions of Inorganic Phosphorus in Indian Soil and Evolution of its Fractionation Schemes: A Mini Review

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(Received 16 June 2022, Accepted 30 July, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: On account of its participation in important physiological processes such as photosynthesis and energy conversion, phosphorus (P) is crucial for all forms of life on earth. The role it plays in maintaining and increasing soil fertility, especially under intensive farming system, is also indispensable. "Solution P," "sorbed P," and "mineral P" are the three broad, theoretically defined pools of soil inorganic P (P_i). Soil P_i might be "labile" or "nonlabile" regarding plant availability. By applying successively stronger extractants to the soil, fractionation produces information about the association of P with various soil phases. The transformation of applied P in soil and the uptake of P by plants are both significantly influenced by fractionation pattern of P, thus making it crucial. As the main physicochemical characteristics of the soil change, the fractionation of P in the soil also varies. The P fractions in Indian soils vary significantly in terms of soil characteristics. Over the past six decades, researchers have come up with several approaches to evaluate various soil P_i fractions as accurately as possible. However, there is still a lot of scope for improvement in terms of designing a robust extraction technique that works in a wide range of soils.

Keywords: Phosphorus, pools, P-fractions, Indian soil, fractionation schemes.

INTRODUCTION

For plants, phosphorus (P) is an essential macronutrient (Chan *et al*., 2021). It is crucial for sustenance and build-up of land fertility, particularly under intensive agriculture (Yasmeen *et al*., 2022). In soil, available P is always in dynamic equilibrium with other forms of P that are not extracted by conventional soil test methodology. One way to know those different forms of P is to study P-fractionation. Numerous investigations have been undertaken on the dynamics of P fractionation in soil system to gain a deeper insight into its fixation and release pattern (Lizcano-Toledo *et al*., 2021). The critical concern in actual practice is to know how much P from the native soil pool can be made available to the crops growing in the field. The average mineral soils contain far less P than other macronutrients such as potassium, calcium, magnesium, or nitrogen. More crucially, plants cannot easily access the majority of the inorganic P (P_i) present in the soil. Even under favourable soil conditions, when soluble fertilizer salts are added to the soil, P is quickly fixed and rendered unavailable to higher plants. Phosphorus in soil fertility faces a three-fold challenge (Mardamootoo *et al*., 2021). First off, the total P level, in general, is low in soils — typically between one-tenth and one-fourth of nitrogen and one-twentieth of potassium content. In the top fifteen cm of a ha of soil, the total P content ranges only from 200 to 2000 kg. Secondly, the common P compounds that are found in soils have very low solubility and contain P mostly in unavailable forms. Thirdly, soluble forms of P, like those found in fertilizers and manures, are fixed and converted into very insoluble compounds once introduced into soils. It has been observed that the vast majority of soils are unable to consistently deliver enough P to plants. Despite sustainability issues, continuous use of P fertilizers can solve this problem in cultivated soils. Given that soil-based fertilizer reaction products are the main source of P to plants, understanding how this element is partitioned into different inorganic forms is crucial (Prasad and Shivay 2021). In addition, it is also essential for comprehending the genesis and fertility of soil. The distribution of different forms of P_i in the soil reflects its chemical characteristics, age, drainage, and mineralogical makeup. The differential fate of applied P fertilizers under varying soil conditions can be traced only with the help of fractionation study. Apart from that, in order to evaluate the P uptake by crops, one must be aware of the quantities of each fraction and the related affecting factors. Since different phosphate forms have varied solubility, their distribution may provide a clue as to the amount of P that is available to plants.

FORMS OF PHOSPHORUS IN SOILS

Soil contains P in both organic and inorganic forms. Knowledge regarding different forms of P is essential for understanding how plants use P and how much P can flow through the environment. Phosphorus is the least mobile of the major plant nutrients. Soil P pools have been conceptualized as "solution P", "sorbed P" , "mineral P" and "organic P" based on their association with various soil constituents (Fig. 1). It is important to note that this concept does not directly address the accessibility, extractability, and plant availability issues of P in soil. Products of all living things, including microbial tissues and plant leftovers, contain organic P. Fresh manure contains about two-third of its P in organic form. The usual share of organic P in soil ranges between 16 and 46% of total P. In India, this may range from 0% in the Rajasthani desert dunes to 92.8% in the Assamese fresh alluvial highlands. Inositol phosphate, phospholipids, and nucleic acids are the three major organic forms of P in soils. The vast majority of P_i ingested by living organisms is transformed into organic compounds *via* immobilization. Organic P is gradually converted to plant-useable inorganic phosphate *via* microbial mineralization when plant (and animal) waste is returned to the soil.

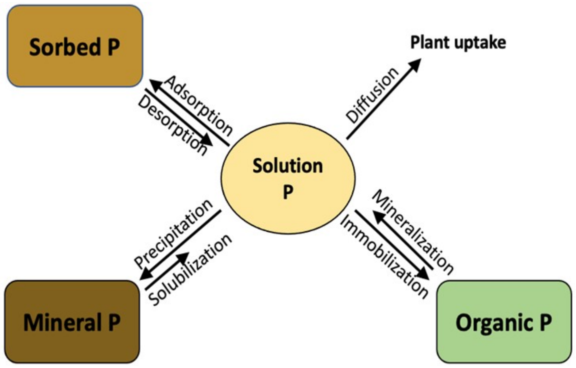

Fig. 1. Soil phosphorus pools and processes.

Despite the fact that organic P may make up a sizeable portion of total soil P, P_i predominates in majority of the situations (54–84% of total P). The P_i pool in soil is comprised of "Sorbed P", "Mineral P" and "Solution P." Phosphorus that has been electrostatically and covalently bound to the surfaces of iron(Fe)- and aluminium(Al)- oxyhydroxides, clay, and calcium carbonate is known as sorbed P. Strongly bound P that has been coated with Fe- or Al-oxyhydroxide layers to make their solubilization even more challenging is referred to as occluded or reductant soluble P. In severely weathered acid red and lateritic soil, the occluded P may constitute as much as 50% of the total P. As the soil ages and weathering becomes more severe, the P-spectrum changes from being dominated by Ca-P to that by occluded-P. The term "mineral P" refers to discrete solid-phase P compounds with a range of surface area and structural arrangement (from crystalline to amorphous); these compounds, such as apatites, might be the result of pedologic processes or the reaction products of P fertilizers applied to the soil (*e.g.* di-calcium phosphate from superphosphates). The phosphate anions in soil solution can bind with cations such as Fe, Al and Ca to form mineral P. Al-P and Fe-P can make up anywhere between 1% and 25% (typically 8–10%) of the total P in soils. In neutral, calcareous and slightly alkaline soil, the Ca-P can make up 40–50% or even more of the total P. All the P pools maintain equilibrium with the soil's orthophosphate through the processes of sorption-desorption (for sorbed P), precipitation-dissolution (for mineral P), and mineralization-immobilization (for organic P). We shall concentrate on the inorganic pool in this review. Soil ‘solution-P’ serves as a central meeting point for all P pools and it regulates the instant supply of P to the plants. The soil solution, however, has a very low P content. In some severely weathered tropical soils, the concentration of phosphorus in the soil solution can be as low as 10^{-8} M (Johnston *et al*., 2014). If the top 30 cm of soil contains 6 cm of water (equivalent to 6 lakh L ha^{-1}) and the concentration of P in the soil solution is 10^{-5} M, or 0.3 mg P L^{-1}, then the solution pool of P will amount to only 0.2 kg P ha^{-1}. Even in the best case scenario, its content hardly ever exceeds 0.5 kg P per ha of plough layer soil. Following the application of P-containing fertilizer to soil, the solution P pool rises for a brief period of time. Soluble P steadily changes over time into less soluble (and therefore less plant-available) forms. The concentration gradient of P between bulk-solution and root surface, the rate of P recharge to solution as it is uptaken, the volumetric soil moisture content, the interconnectivity of water films inside pores, and soil P buffering capacity are some of the factors that have an impact on the sustained supply of P (in the form of H_2PO_4- and, to a lesser extent, $HPO_4^{=}$) to the plants.

The organic and inorganic reserves of P associated with different soil solid phases replenish the phosphate ions depleted from the soil solution. Based on the ease of availability, these reserves are categorised as either "Labile" or "Nonlabile" While nonlabile P equilibrates slowly and refill the labile reserves gradually over time, labile P promptly equilibrates with the soil solution P and becomes available (Fig. 2). Irrespective of the mechanism by which P is retained in soil, soil P_i can be conceptualized to be in four pools on the basis of its accessibility, extractability and availability to plants (Syers *et al*., 2008; Johnston *et al*., 2014). Although P can be present in soil in both inorganic and organic forms, the former has received the majority of attention in study.

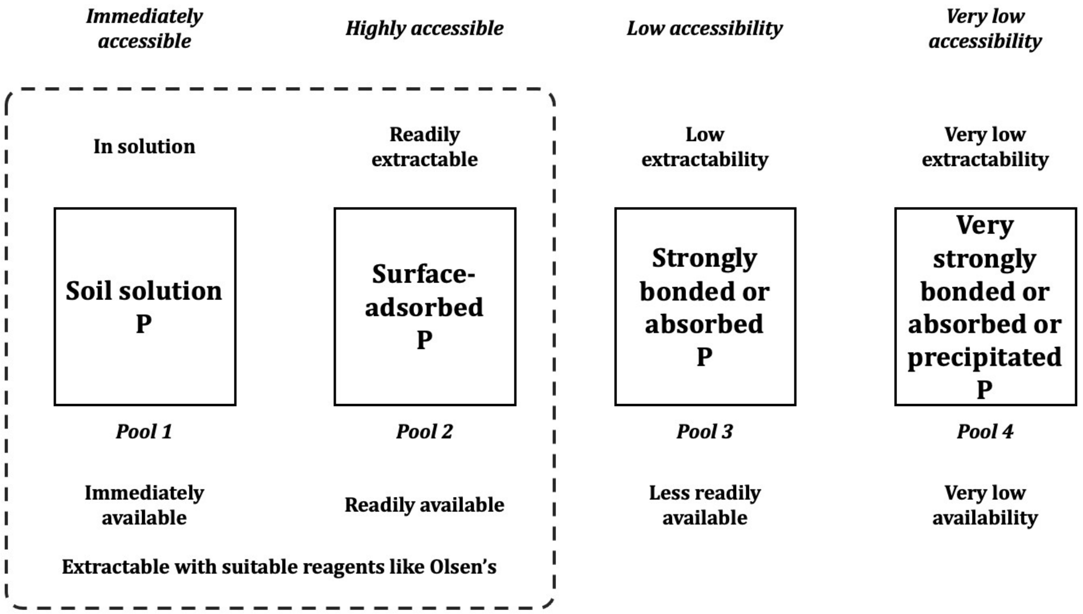

Fig. 2. Conceptual Pools of inorganic phosphorus in soils classified in terms of accessibility, extractability, and availability to plants.

INORGANIC PHOSPHORUS FRACTIONATION SCHEMES

A variety of fractionation schemes and soil test procedures have been developed so far to understand the P_i status and its availability in soil. The fractionation procedures are based on the differential solubilities of various P_i forms against various extractants. The P fractions have been proven to be useful in understanding how applied P fertilizer transforms in soils and also in interpreting P-soil-test outcomes. Inorganic P can react with Ca, Al, or Fe in soil to yield discrete phosphate-minerals with meagre solubility such as hydroxyapatite [$Ca_{10}(PO_4)_6(OH)_2$], octacalcium phosphate [$Ca_8H_2(PO_4)_6.5H_2O$], variscite ($AlPO_4.2H_2O$), and strengite ($FePO_4.2H_2O$) *etc.* Most P fractionation procedures involve the separation of "loosely bound P" using a salt solution (such as 1 *M* NH_4Cl), followed by Fe- and Al-bound P using a mixture of alkali reagents (0.1 *M* NaOH, 0.5 *M* $NaHCO_3$), and lastly Ca-bound P using acid (0.5 *M* HCl, 0.5 *M* H_2SO_4). Researchers have come up with a number of P_i fractionation techniques in the last sixty years to investigate the P_i transformation in soils and sediments of a variety of natural as well as man-made ecosystems. These cover specific techniques for determining only inorganic (Chang and Jackson 1957; Hieltjes and Lijklema 1980; Kuo, 1996), both organic and inorganic (Van Eck, 1982; Psenner, 1988; Ruttenberg, 1992; Golterman *et al.*, 1997; Chen *et al.*, 2000; Pardo *et al.*, 2003; Tiessen and Moir 2008), and combinations of organic, inorganic and microbial forms of P (Hedley *et al.*, 1982). The fractionation scheme developed by Chang and Jackson has been extensively used to investigate the forms of P_i and fate of added P fertilizers. Later, investigators realized that various extractants of this scheme were not as specific as originally thought. When Chang and Jackson's (1957) method is employed to fractionate P in calcareous soils and sediments, retention of P by calcium fluoride (CaF_2), which is generated from the reaction of calcium carbonate ($CaCO_3$) and ammonium fluoride (NH_4F), impacts result. Several researchers, later on, modified the procedure and enabled its usage with wide spectrum of soils. Kuo *et al.* (1996) described the most significant changes among them (Fig. 3).

Despite criticism regarding the efficiency of Chang and Jackson's extractants on pure compounds, very little attempt has been made to systematically explore the extraction-yield of P from common solid phases present in soil. This research gap has been created as because accurate separation of different solid phases from soil is unfeasible. Williams *et al.* (1980) employed a mixture of citric acid, dithionite and bicarbonate (CDB), at a relatively high pH, followed by NaOH and, HCl. The CDB was meant to extract Fe-P, leaving the organic P to be extracted by NaOH. The HCl was supposed to be specific for Ca-P. It wasn't recognised for quite a long time that NH_4F and NaOH both promote the formation of hydroxyapatite. Not only does this apatite formation affects the outcomes undesirably, but the amount of P hydrolyzed by NaOH is also inconsistent. The amount of P brought into solution by NaOH is often influenced by the length of extraction period and the strength of NaOH, thus, it is difficult to assign a specific P fraction against this extractant. The concentration of extractable P either increases or decreases with duration. Re-adsorption onto $CaCO_3$ is what causes the drop, whereas the hydrolysis of the recalcitrant organic P is what causes the increase.

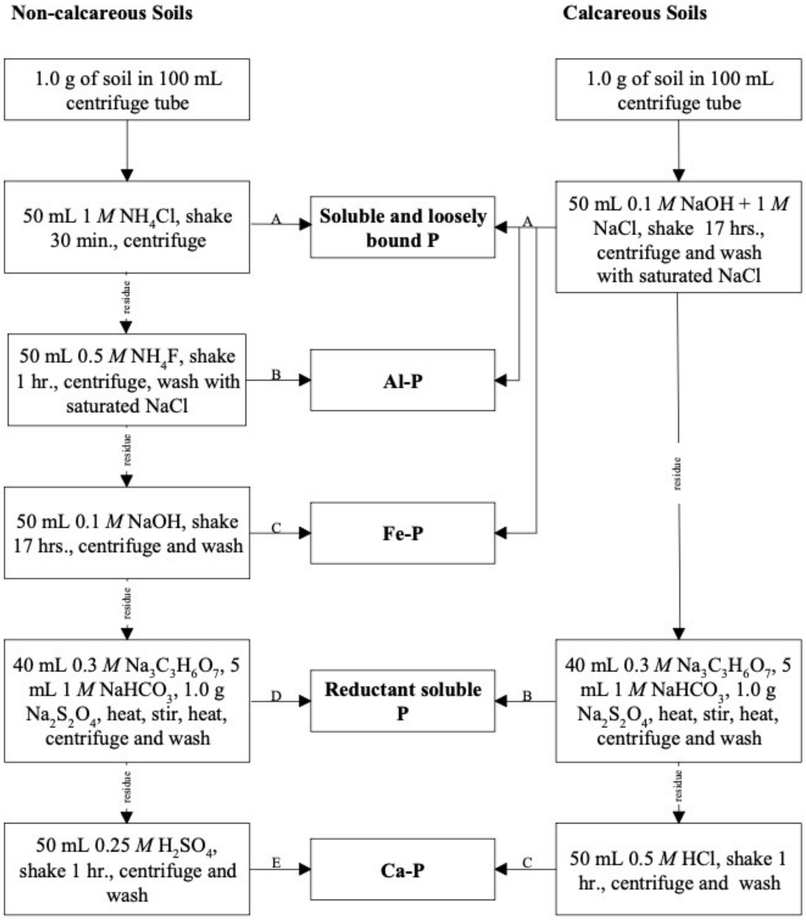

Fig. 3. Inorganic phosphorus fractions in non-calcareous and calcareous soils (adapted from Kuo *et al*., 1996).

Therefore, the relative abundance of these compounds in soil affects the concentration of extracted P. Psenner (1988) employed a modified reducing agent, namely dithionite-bicarbonate (without citrate), in the first step. Unfortunately, this made the following steps questionable since the dithionite-bicarbonate removed only the P associated with Fe-compounds and not the ferric oxyhydroxide itself. The next step involving NaOH was supposed to extract organic P or non-reactive P, but the problem of the hydrolysis of organic P was not fully addressed. The subsequent steps involved extraction with HCl, succeeded by hot NaOH. The hot alkaline hydroxide extracted merely 10% of what was extracted by cold NaOH in the second step. It was unclear how much of the ferric oxyhydroxide was eliminated by the extractants, which could be an important lead for further investigation. The SEDEX extraction sequence was developed by Ruttenberg (1992) which had CDB as its first extractant, followed by acidic sodium acetate (at pH 4), and, finally, H_2SO_4. Golterman *et al*. (1997) discovered that EDTA removed more Ca-P than what was combinedly extracted by acidic sodium acetate and H_2SO_4 in Ruttenberg's scheme. There are other fractionation techniques, such as the iron-oxide stripping method of House *et al.* (1995) which, as its drawback, requires multiple extractions. Huettl *et al*. (1979) added aluminium hydroxide to a cation exchange column to determine the quantity of adsorbed phosphate, and this was termed as P_{ad}. While employing this step, it's important to be aware of a number of potential sources of errors, some of which include partial P recovery from the exchanger and incomplete P transfer to the exchanger. Jiang and Gu (1989) developed their fractionation scheme based on the capacity of $NaHCO_3$, NH_4F, NaOH, Na_2CO_3 and H_2SO_4 to extract $CaHPO_4.2H_2O$, $Ca_8H_2(PO_4)_6$, $AlPO_4.nH_2O$, $FePO_4.2H_2O$ and $Ca_{10}(PO_4)_6F_2$, respectively. Solis and Torrent (1989) showed that CDB-extractable Fe was related to occluded P, and that the occluded P was associated with the crystal structure of Fe-P minerals. Even in calcareous soils, studies have revealed that the presence of even minute quantities of iron or aluminium oxides controls P behaviour (Samadi and Gilkes 1998). The sequential fractionation of soil P developed by Hedley *et al.* (1982) differentiated between bioavailable and unavailable forms of P within the P cycle. Hedley fractionation uses anion exchange to remove labile soil P from the soil solution. Subsequently, stronger reagents are used to extract additional forms of soil P that are more tightly attached to soil surfaces or are less biologically accessible. This fractionation is frequently used to assess how management has affected the soil P forms. This method extracts five fractions: resin-P, bicarbonate-P, NaOH-P, HCl-P, and H_2SO_4-H_2O_2 digest (residual) P. The forms of P that can be easily exchanged from soil particles include resin-P and bicarbonate-P. The NaOH-P is less available to plants because it is that P which is attached to or precipitated on hydrous oxides or clay edges. In P fractionation, residual P is the totally recalcitrant form of P which is believed to be in its most stable form. Due to its high resistance, residual P is removed from the soil using highly powerful chemicals like peroxide and mineral acids. This fraction consists of humified organic P and precipitated, crystalline P_i compounds (Hedley *et al*., 1982; Zhang *et al*., 2008).

SOIL PROPERTIES AND MANAGEMENT PRACTICES AFFECTING PHOSPHORUS FRACTIONATION

The relative amount of soil-P fractions present in any soil are very much dependent on pH, degree of weathering, organic matter, cropping system and fertilizer practices. Chand and Tomar (1993) conducted an eight-week-long incubation experiment with twenty eight alkaline soils to study the effect of soil properties on apportionment of added as well as native soil P into different P_i fractions. In all the soils, proportion of saloid-P and Al-P dropped, while native Fe-P, Ca-P, and Olsen's-P increased with time. With rising CEC, active Fe, clay, and organic carbon content, the tendency of the added P to enrich the saloid-P fraction decreased logarithmically. More P entered into Ca-P fraction with rising pH and calcium carbonate content, whereas, the opposite was observed in case of Fe-P. One unit elevation in pH resulted in 9.3% increase in the recovery of added P as Olsen-P, while the same decreased to the tune of 15.6 and 0.6% with each per cent increase in organic carbon and clay content, respectively. The available P showed significant positive correlation with saloid-P but the same was not observed with Al-, Fe- or Ca-P. The cumulative contribution of all the P fractions to available P was 86% in the studied soils. Sharma and Tripathi (1992) studied the P fractions in the surface layers of some hilly acid soils collected from north-western part of India. The preponderance of reductant soluble P was most likely the cause behind low-land rice crops' little response to applied P in this region. As revealed by the relative distribution of different fractions of P, majority of the soil samples (about 92%) were in an advanced stage of weathering, while remaining samples were only mildly worn. Only clay content had a discernible impact on the soil's overall and Fe-P contents. Amorphous and total Fe accounted for the largest variation in the Fe-P fractions, whereas total and extractable Al was significantly connected to the formation of Al-P. There was no association between forms of Ca and Ca-P fraction. The variation in extractable and amorphous Fe, on the other hand, accounted for the majority of the variation in reductant soluble P. Studies focused on the effect of long-term nutrient management and cropping pattern on inorganic soil P fractions reported increased amount of saloid-, Fe-, Al-, reductant soluble-, and available-P in the soils receiving NPK at recommended dose in comparison to the control. Nunes *et al.* (2020) studied the impact of long-term tillage and fertilizer management on the distribution of soil P fractions and observed that, as compared to conventional tillage, no-tillage led to higher P_i build-up in labile fractions, whereas, organic P was partitioned more inside protective aggregates. Also, there was an increase in the Ca-P fraction when reactive rock phosphate was used under no-tillage instead of triple super phosphate under conventional tillage. This increase in the Ca-P was more prevalent when the fertilizer was broadcast. Mahawar *et al.* (2022) showed that application of FYM @5 t ha^{-1} could significantly increase the proportional abundance of saloid-P fraction. It should be noted in this regard that saloid-P represents that fraction of P which is almost instantly accessible to plants.

INORGANIC PHOSPHORUS FRACTIONS IN INDIAN SOILS

The relative proportion of P fractions is largely controlled by their solubility and reactivity in soils. Fe-P and Al-P are difficulty soluble compounds at low pH and so is Ca-P at high pH. However, P forms relatively more soluble compounds with Ca^{2+} and Mg^{2+} at near neutral pH. The principal active forms of P_i that contribute at different degrees in the available P pool are soluble or loosely bound P, Al-P, Fe-P, and Ca-P. The occluded and reductant-soluble versions of P are both less active. Although their proportions vary, all the fractions of P are generally found in every soil. Acid soils have more Al-P and Fe-P, whereas, neutral to alkaline soils have more Ca-P. Phosphorus is assumed to be associated to Na in sodic soils and it is extremely mobile. Except in lowland rice, the reductant soluble P fraction in soil, in general, is insoluble enough to be of any practical importance. Several scientists have made contribution to the identification of different fractions of P_i in Indian soils. As per Singh and Sharma's (2007) report, saloid-P, Fe-P, Al-P, and Ca-P ranged from 1.5–4.2, 1.4–14.0, 12.8–29.8 and 17.8–328 mg kg^{-1} in soils collected from different agro-ecological zones of Punjab. In three major agricultural valleys of Himachal Pradesh, saloid-P, Fe-P, Al-P, and Ca-P fractions ranged from 0.2 to 22.5, 4.1 to 120.3, 0.3 to 89.4, and 14.8 to 400.4 mg kg^{-1}, respectively (Jaggi, 1991). Because of differential P management approaches, the saloid-P and Fe-P did not show any obvious trend in these valleys. According to Patiram and Prasad (1990), Fe-P predominated among the various forms of P identified in the acid soils of Sikkim, being around 1.5 times more abundant than Ca-P or Al-P, whereas, Ca-P and Al-P differed little from one another in terms of abundance. Additionally, they stated that residual P had a negative correlation with other kinds of P_i but was substantially related to total and organic P. Laxminarayana (2007) investigated the distribution of saloid-, Al-, Fe-, and Ca-P in rice soils of Kolasib district, Mizoram, and found that those ranged from 3.25–9.03, 29.6–46.8, 18.2–33.7, and 22.4–39.4 mg kg^{-1}, respectively, with the total P content ranging from 132.3–365.8 mg kg^{-1}. The available P pool in the

Kolasib rice-soil was largely made up of Al-P, Fe-P, and Ca-P fractions. Following are the P-fractions' relative abundances in various soils: Al-P (19.6%) > Fe-P (15.8%) > Ca-P (12.0%) > Saloid-P (2.46%). According to Perumal and Velayutham's (1977) observation, Al-P and Fe-P made up 55% of the total P while Ca-P made up just 12% of the same in rice soils. However, unidentified residual P and saloid P accounted for the highest and lowest individual shares of total P, respectively. Reductant soluble P and Ca-P had similar abundance in those rice soils. The distribution of P in Indian Alfisols falling under the pH range of 5.5 to 6.8 was Fe-P > Ca-P > Al-P (Sahrawat, 1977). Doddamani and Seshagiri Rao (1989) investigated different forms of P in soils of Karnataka and found that Ca-P constituted the dominant share of total P in Vertisols (upto 19.5%) and Inceptisols (upto 11.5%). Fe-P constituted 14.2, 9.1, 2.5, and 2.4% of total P in Oxisols, Alfisols, Vertisols and Inceptisols of Karnataka, respectively. Highest amount of reductant-soluble P was found in Oxisols followed by Alfisols, Vertisols and Inceptisols. Occluded and saloid P accounted for 2.9–3.0 and 0.5–0.6%, respectively, of the total P in the soils of Karnataka. Viswanatha and Doddamani (1991) also found Ca-P to be the dominant fraction of P in alkaline Vertisols of Karnataka. According to Rao and Krishnamurthy (2007), the distribution of P_i fractions, such as saloid-, Al-, Fe-, and Ca-P in the soils of Andhra Pradesh's Khamman district ranged from 13.5–78.4, 45.0–499, 6.2–47.9, and 6.9–438.2 mg kg^{-1}, respectively. In the rice soils of West Bengal, Al-P, Fe-P, Ca-P, reductant soluble P and occluded P fractions made up approximately 7.2, 27.8, 46.6, 16.2, and 2.2% of the total inorganically bound P, respectively (Mandal, 1975). Debnath and Mandal (1982) also found Ca-P to be the dominant fraction of P in West Bengal soils. They reported the respective ranges of Ca-P, Al-P and Fe-P as 41.4–328.4, 21.4–120.4 and 57.1–142.8 and mg kg^{-1}. Adhikari and Si (1994), however, observed that Fe-P is the leading fraction of P_i in the acidic soils of West Bengal. In their study, saloid-P, Al-P, Ca-P, Fe-P and total P varied from 5.4–15.0, 11.2–18.0, 9.5–31.0, 32.5–41.8 and 122.9–190.1 mg kg^{-1}, respectively. Dutta and Mukhopadhyay (2007) worked with acid (pH 4.21–5.67) soils of north Bengal having moderate to high organic carbon content and their findings revealed that Al-P was the chief form of P_i in those soils, followed by Fe-P. In some coastal soils of West Bengal the major extractable P_i fractions followed the order of Ca-P > Al-P > Fe-P. Lungmuana *et al.* (2012) studied the distribution of P in the rice-growing red and laterite soils of West Bengal and reported that the average contribution of different P_i fractions towards total P was in the order of Fe-P (18.5%) > Al-P (7.9%) > Ca-P (5.8%) > saloid-P (0.8%).

CONCLUSION

Phosphorus plays a vital role in enriching and sustaining soil fertility. Solution P, sorbed P, and mineral P are the broad conceptually defined pools of soil P_i. Soil P_i can be 'labile' or 'nonlabile' in terms of plant availability. By sequentially treating the soil with increasingly stronger extractants, soil fractionation generates information regarding the partitioning-pattern of P with different soil phases. Knowledge about various forms of any nutrient in soil is essential since not all the forms contribute equally to a specific process. Analytical fractionation of soil P has been used in studies pertaining to the development of soil tests for P, assessment of the contribution of various P fractions to crop nutrition, conversion of added fertilizer P into various soil P fractions, prediction of crop response to applied P, and as a weathering index. In neutral, alkaline, calcareous, and sodic soils, Ca-P is the dominant fraction. Whereas, in acid, red, and lateritic soils, Al- and Fe-P predominate. Plant P uptake is invariably connected to Al-P and Fe-P, and this has been observed even in Ca-P dominating soils. Under reducing conditions, a significant portion of Fe-P (and in some cases, occluded P) is rendered soluble and becomes crucial in rice crop nutrition. Legumes and oilseed crops require a great deal of Ca-P. In Entisols, correlation studies have revealed that Al-P and Fe-P are more important sources of bioavailable P than Ca-P. Chemical weathering is measured by the distribution of P_i in soils, with Ca-P getting weathered first, followed by Al-P, Fe-P, and occluded-P. As the primary physicochemical parameters of soil change, so does the fractionation of P in soil. Over the last six decades, experts have presented many techniques to quantify various fractions of soil P. However, more efforts remain to be put in terms of developing a consistent extraction technology that works in wide spectrum of soils.

FUTURE SCOPE

There is a large scope of assessing the fractionation of P in different soil types of India subjected under varying management practices. In future, researchers should come up with more efficient fractionation schemes which show better selectivity of extractants to specific P fractions and, at the same time, are easy to follow in laboratory.

Acknowledgement. Authors acknowledge Mr. Kousik Atta and Mr. Manojit Chowdhury for their help during formulation of the manuscript.

Conflict of Interest. Nil

Author contributions: AD and AR have contributed equally in strategizing, reviewing literature and writing the paper. DP and AC helped in writing the paper.

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How to cite this article: Anwesha Das, Arkaprava Roy, Dolgobinda Pal and Animesh Chowdhury (2022). Pools and Fractions of Inorganic Phosphorus in Indian Soil and Evolution of its Fractionation Schemes: A Mini Review. *Biological Forum – An International Journal*, *14*(3): 888-895.