

NOTE

**EFFECT OF ADDED P ON CaCl_2 -AND
 NaHCO_3 - EXTRACTABLE P OF SOILS OF
THE DOWNSTREAM DOROODZAN DAM
AREA OF IRAN**

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ABSTRACT

The relationship between water soluble and NaHCO_3 extractable-P was investigated in major soils of downstream area of the Doroodzan dam in Fars province. Seven composite soil samples from 0-5 cm depth of soil series of Beyza, Hesamabad, Korbai, Kooshkak, Kor, Ramjerd and Takht-e-Jamshid were collected, and samples of each were treated by adding 0, 45, 90, or 180 mg P kg^{-1} soil as KH_2PO_4 . Soluble P in water was measured after 2 hr shaking by Murphy and Riley method (11). Extractable-P was determined based on Watanabe and Olsen method (17). There was a linear relationship between NaHCO_3 and applied P and also a linear relationship between the soluble and extractable-P on the log-log basis for 7 soil series under study. The relationship between soluble P and added P was found to be dependent on the CEC of the soil. A general equation was presented to describe this relationship considering CEC of the soil series.

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اثر اضافه شدن فسفر روی فسفر قابل عصاره گیری با کلرور کلسیم و بی کربنات سدیم در خاکهای زیر سد درودزن ایران

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چکیده

برای مطالعه و بررسی رابطه بین فسفر محلول و قابل عصاره گیری در خاکهای مهم زیر دست سد درودزن در استان فارس ۷ نمونه ترکیبی از عمق ۵-۰ سانتی متری خاکهای سری بیضا، حسام آباد، کربال، کوشکک، کر، رامجرد و تخت جمشید برداشته شد. برای تعیین رابطه بین فسفر قابل عصاره گیری با آب و فسفر قابل عصاره گیری با بی کربنات سدیم مقدار ۰، ۴۵، ۹۰، ۱۸۰ میلی گرم در هر کیلوگرم خاک فسفر به صورت KH_2PO_4 به نمونه ها اضافه شد. فسفر محلول در آب با متد *Murphy* و *Riley* (۱۹۶۲) بعد از ۲ ساعت تکان و فسفر قابل عصاره گیری با روش *Watanabe* و *Olsen* (۱۹۶۲) اندازه گیری شدند. نتایج تحقیق نشان داد که رابطه بین فسفر قابل عصاره گیری با بی کربنات سدیم و فسفر اضافه شده خطی است. همچنین یک رابطه خطی بین لگاریتم فسفر محلول و لگاریتم فسفر قابل عصاره گیری با بی کربنات سدیم وجود دارد. رابطه بین فسفر محلول و فسفر اضافه شده به خاک بستگی به *CEC* خاک دارد. معادله ای که رابطه مذکور را تعیین می کند با توجه به *CEC* در مقاله ارائه شده است.

INTRODUCTION

When a phosphorus fertilizer is added to the soil, it first dissolves and then enters into a series of precipitations or sorption reactions resulting in greatly reduced level of phosphate in soil solution (9, 14, 15). The level of dissolved P in soil solution is controlled by various equilibrium reaction mechanisms existing in the soil. The concentration of dissolved P in the soil

solution(9, 14, 15). The level of dissolved P in soil solution is controlled by various equilibrium reaction mechanisms existing in the soil. The concentration of dissolved P in the soil solution and the capacity of solid phase to replenish phosphate as it is removed from soil solution are important factors in determining the P availability to plant and the amount of P loss from soils by runoff and leaching(8).

Adsorption - desorption reactions of P are relatively rapid in the soils. several investigators have shown that the phosphate desorption from soils and calcite is rapid and follows first order reaction kinetics(7, 12).

Römken and Nelson (14) showed that there was an approximate linear relationship between available P in soil and water extractable P with addition of up to 100 mg P kg⁻¹ as KH₂PO₄. Oloya and Logan (12) concluded that extractable-P,(Bray-P₁) was a good indicator of P desorption from soils and sediment. Amin Sichani (2) found that the logarithm of released P from soil linearly correlated with that of extractable-P (Bray - P₁).

The major studies on the loss of soluble P from agricultural lands have been in non-calcareous soils and similar investigations are not reported in Iran. the present research was conducted to determine the relationship between added P and extractable-P, and between dissolved P and extractable-P of the soils of the downstream of the doroodzan dam area of Iran.

MATERIALS AND METHODS

The study area, i. e., downstream of Doroodzan dam area (Fig.1) is located in Kor river alluvial plain about 50 km north-east of Shiraz in Fars province(18).

Seven soil series that constituted greater than 85 percent of total area at downstream of Doroodzan dam were selected. The name of each soil series on USDA taxonomy, and their physical and chemical characteristics are shown in Table 1 (3). the soil samples were air-dried and passed

through a 2 mm sieve . Particle-size distribution of the soil samples was determined by pipette method after removal of CaCO_3 and organic matter(6). Calcium carbonate equivalent was measured by treatment with 0.5 N HCl and titrating with 0.25 N NaOH(1). Organic matter content was determined by Walkley-Black method(4). Soil pH was measured with glass electrode in a 1:2.5 soil: water suspension(13). Cation-exchange capacity was determined by sodium saturation method(5).

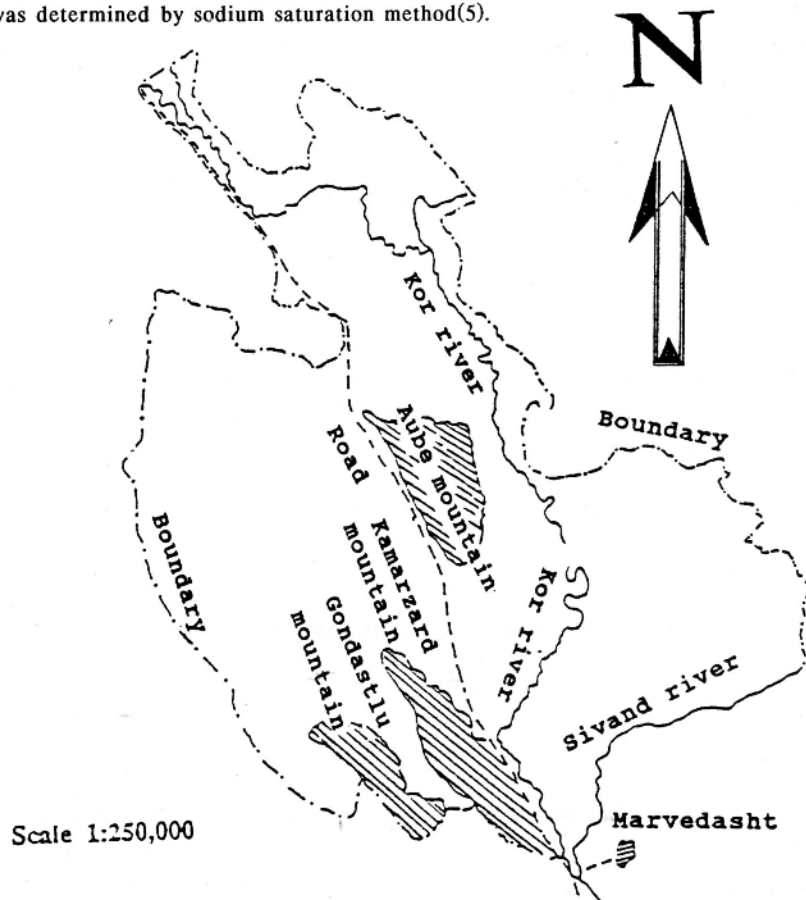


Fig 1. Study area in the downstream of Doroodzan dam.

Table 1. Taxonomy, area, physical and chemical characteristics of soils of the downstream area of the Doroodzan dam.

Soil Series	USDA soil taxonomy	Area (ha)	pH	CaCO ₃ equivalent (gkg ⁻¹)	Cation exchange capacity (cmol _c kg ⁻¹)	Organic matter (gkg ⁻¹)	Particle Size Distribution - %				
							Clay	Fine silt	Coarse	Sand	
Beyza	Haplic	Xerosols	3180	8.4	475	16.1	14.3	62.2	28.3	6.7	2.8
Hesamabad	Calcic	Xerosols	4470	8.2	514	15.5	6.1	38.8	3.7	14.3	7.2
Korbal	Aquolic	Salorthids	5760	8.5	480	11.5	8.9	44.3	40.7	9.1	5.09
Kooshkak	Haplic	Xerosols	30870	8.3	520	13.9	13.9	54.7	30.8	9.4	5.1
Kor	Calcic	Regosols	7810	8.3	520	12.8	10.9	42.9	28.9	17.7	10.5
Ramjerd	Calcic	Xerosols	6200	8.4	482	20.1	34.1	59.4	28.6	8.6	3.4
Takhte											
Jamshid	Calcic	Xerosols	9864	8.3	397	17.4	16.3	66.6	22.6	7.7	2.9
Total			68154								

One hundred grams of each soil sample were wetted with KH₂PO₄ solution at P application rates of 0, 45, 90, 180 mg kg⁻¹soil (for Kooshkak and Ramjerd soil series additional P rates of 360, 720, and 1080 mg kg⁻¹ soil were also employed) at water content of 30%(w:w). Treated samples were prepared in three replicates and their containers were covered by perforated parafilm. The samples were incubated at the laboratory temperature for three days before soluble P was determined.

In all treatments concentration of CaCl₂ was 0.01 M to flocculate the suspension when centrifuged. Moreover, to prevent the activity and growth of microorganisms, 2 to 3 drops of toluene were added to each soil-water mixture. The soil water mixture was shaken for 2 hr(18). Approximately 45 ml of each suspension were centrifuged at 2000 rpm for 15 to 20 min until a clear supernatant was obtained. The supernatant was filtered through Watman No. 42 filter paper. The amount of soluble P in the filtrate was determined as Murphy and Riley method (11). Extractable-P was determined as described by Watanabe and Olsen(17). Five

grams of air dried soil were added to 100 ml of 0.5 M NaHCO₃(pH 8.5). The sample was shaken for 30 min and filtrated. The amount of the extractable-P was measured by Murphy and Riley method(11).

To determine the proper shaking time, three soil series namely Ramjerd, Kooshkak, and Korbali were used in a separate experiment in which water extractable-P (WEP) at various rates of P was determined at shaking times of 0.083, 0.25, 1, 2, 3, 4 ,6, and 24 hr.

RESULTS AND DISCUSSION

The relationship of the CaCl₂-extractable P and shaking time is shown in Fig.2.

The CaCl₂-extractable P, WEP increased sharply with increasing shaking time up to half an hr. Thereafter, there was a little increase in water extractable-P with respect to shaking time. About 85% of the water extractable-P were released in less than 30 min. Therefore a 2-hr shaking time is sufficient to ensure complete P release for all of the 7 soil series. As Fig. 2 shows with addition of P, the WEP increased i.e., Kooshkak soil. This soil had 1.25 mg kg⁻¹ and 27.5 mg kg⁻¹ P application, respectively.

Barrow (4) Showed that the relationship between NaHCO₃- extractable P (EP) and applied P (P_a) was governed by the following equation:

$$EP=6.1+0.147P_a \quad (r^2=0.978) \quad [1]$$

in which EP is NaHCO₃-extractable-P mg P Kg⁻¹ of soil and P_a is added P mg P Kg⁻¹ soil.

The results of this study indicated that for each soil series the following linear relationship between NaHCO₃ extractable-P, EP and applied P, P_a could be presented.

$$EP = a + b P_a \quad [2]$$

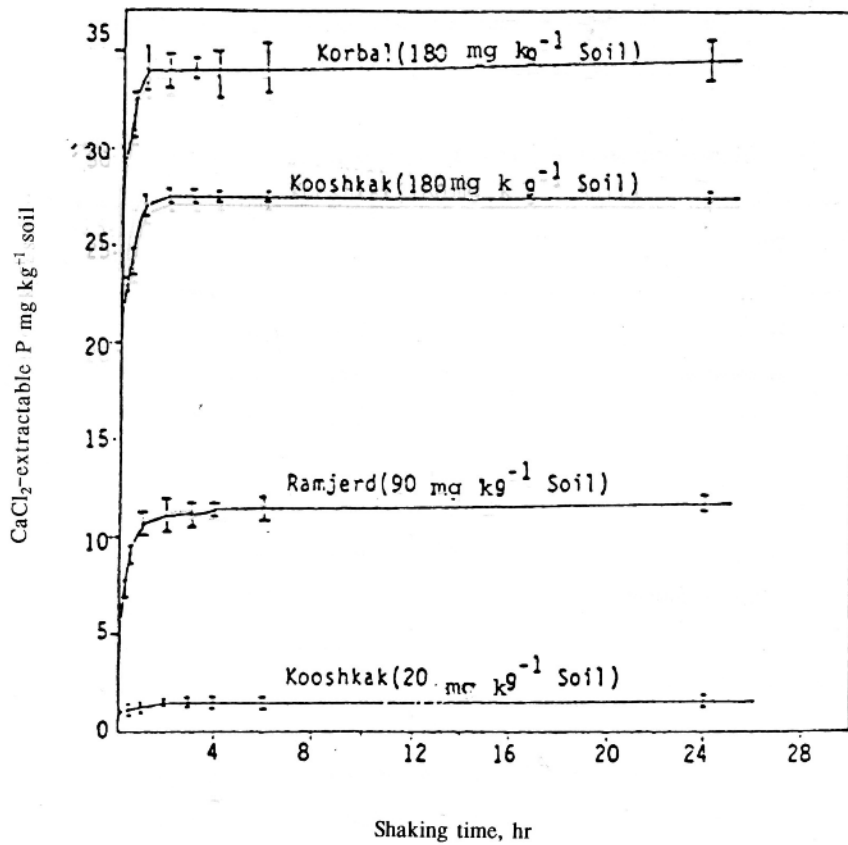


Fig 2. The water extractable-P as a function of shaking time for different soils and P application rates.

in which :

EP is NaHCO_3 extractable-P mg P kg^{-1} of soil.

a is NaHCO_3 extractable-P where no P was added.

b is the slope of the line. The values of a and b are shown in Table 2 for the 7 soil series in our experiment.

Table 2. Linear regression between NaHCO_3 extractable-P and applied P.

Soil series	a	b	R ²
Beyza	27.4	0.55	0.998**
Hesamabad	15.9	0.49	0.991**
Korbal	6.3	0.70	0.998**
Kooshkak	11.1	0.68	0.996**
Kor	5.3	0.61	0.996**
Ramjerd	24.8	0.53	0.997**
Takht-e-Jamshid	14.7	0.53	0.987**

**significant at 1% level.

The values of a varies from 5.3 for Kor soil series to 27.4 for Beyza soil series. This variation is probably due to the P fertilization history of the soils used in our experiment. The slope of the line, b, probably depends on the physical and chemical properties of the soils which needs further experiment in the future. Coefficient b varies between 0.49 for hesamabad and 0.70 for Korbal and on the average had a value of 0.5 for the 7 soil series in our study. This mean that about half of the P added to the soil could be extracted with NaHCO_3 after 30 minutes

shaking, under the conditions of the present study.

A multiple regression analysis showed that the coefficient a is dependent on CEC of the soil series. Therefore, equation [2] could be presented as follows for all soil series in our study.

$$EP = 0.0054 (CEC)^{2.86} + 0.58 P_a \quad [3]$$

in which CEC is cation exchange capacity of the soil in $\text{cmol}_c \text{kg}^{-1}$ soil, EP and P_a are defined as before.

The relationship between water extractable-P, WEP, and NaHCO_3 extractable-P, EP, is linear on the log-log basis. The general equation governing that relationship is:

$$CEP = K (EP)^{\beta'} \quad [4]$$

Where:

CEP is CaCl_2 - extractable P mg P kg^{-1} soil

EP is NaHCO_3 - extractable P mg P kg^{-1} soil

β' is the slope of the line

Table 3 shows the values of β' for the 7 soil series under our experiment.

Table 3. values of β in equation [4] for the soils series under study**.

soil series	β'
Beyza	2.25
Hesamabad	1.56
Korbal	1.66
Kooshkak	1.87
Kor	1.59
Ramjerd	3.02
Takht-e-Jamshid	2.05

** All relationships are significant at 1% level.

As the Fig. 3 shows, a linear logarithmic relationship exists for all seven

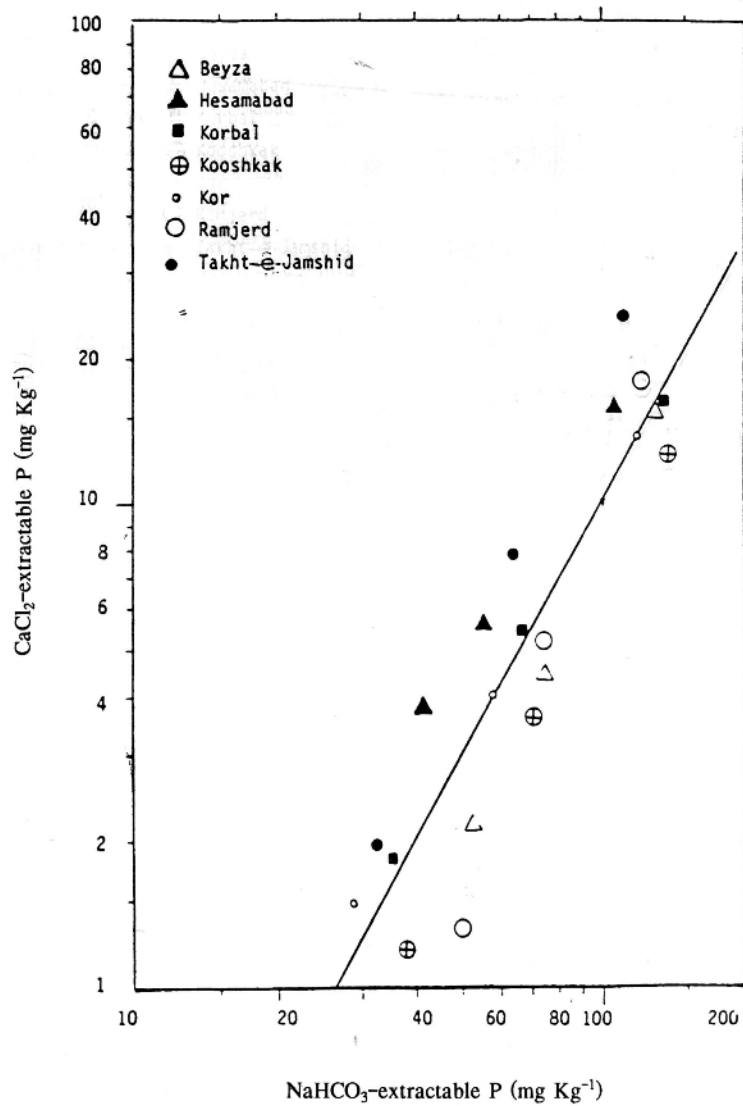


Figure 3. relationship between CaCl₂- extractable P and NaHCO₃- extractable P for 7 soil series under study.

soil series according to equation [4]. The general form of the equation [4] for all seven soil series could be presented as:

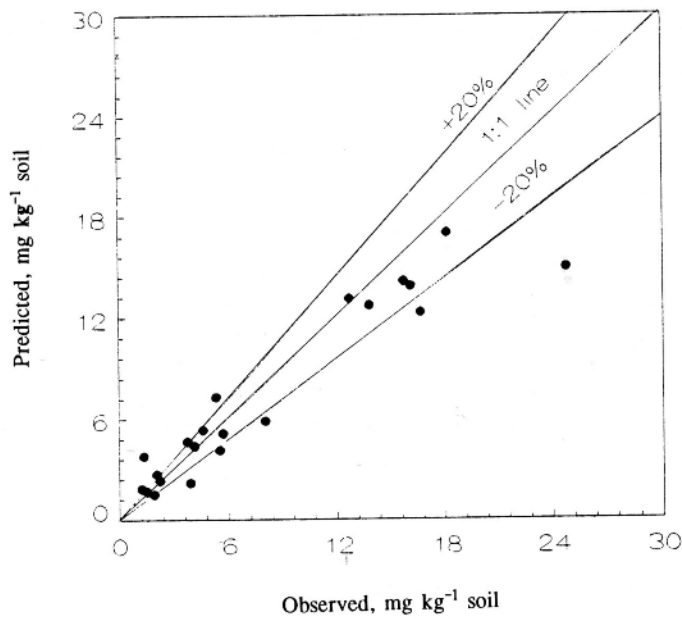
$$\text{CEP} = 4.15 \times 10^{-3} (\text{EP})^{1.70} \quad [5]$$

Now by combining the equations [3] and [5] the following relationship between the CaCl_2 - extractable P and CEC and applied P (P_a) could be adopted:

$$\text{CEP} = 4.15 \times 10^{-3} [0.0054 (\text{CEC})^{2.86} + 0.58 P_a]^{1.7} \quad [6]$$

All the items of equation [6] are defined before. If the CEC and the level of the applied P or existing P in a soil are known the CaCl_2 - extractable P could be calculated by equation [6].

The observed and predicted CaCl_2 -extractable P by equation [6] are shown in Fig 4. As the figure shows equation [6] can predict CEP at various applied P up to



180 mg P Kg⁻¹ of soil. This is corresponding to 150Kg added P per hectare per 5cm depth of the soil. Therefore, equation [6] could predict the CEP for the normal added P or existing P of the seven soil series under our study.

Equation [6] also represents the amount of the water soluble phosphorus which is a very important factor in deterioration of the water quality of the rivers and standing waters. This equation also could be used in the water quality models for prediction of the soluble phosphorus in the runoff from agricultural watersheds.

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