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# THE USE OF $^{65}Zn$ FOR DETERMINING SEVERAL SOIL CHARACTERISTICS

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## ABSTRACT

Three experiments have been carried out to determine (1) zinc fixation capacity, (2) zinc transformation in sub merged condition, and (3) capacity factor (buffering capacity) of zinc using $^{65}Zn$, a gamma emitter radioisotope with a 243.6 days half life. By using $^{65}Zn$ it was able to show that there was difference in zinc fixation capacity of the soils used ranging from 2% - 42%. With the radioisotope it could be determine that after 24 hours the $^{65}Zn$ applied was already retained by the soil up to more than 90%. For the capacity factor of the soil data obtained revealed that it range from 270 - 2400. Some of the data obtained were, % $^{65}Zn$ fixed in soil ranged as follows for soil from: Pusakanegara (42,56%) > Bogor (42,19%) > Pasar Jumat (26,10%) > Batumerta (2.50 %). For % $^{65}Zn$ found in soluble form in submerge condition after: 3 weeks (range 0.05% - 0.23%) < 2 weeks (range 0.18% - 0.40%) < 24 hours (range 0.17% - 2.44%). The lowest capacity factor was obtained by soil from Batumerta (270), followed by soil from Pasar Jumat (714) and Bogor (1000) and the highest was for soil from Pusakanegera (2400).


*Keywords* : zinc fixation capacity, radio isotope, soil characteristics, gamma emitter radioisotope

Zinc is one among the seven micro-nutrients absolutely necessary for plant growth (Channal & Kandaswany, 1997) . It mainly serve as a metal component of a series of enzymes which in turn regulate the physiological factors of the plant. One of these enzymes is tryptophan a precursor of indole asetic acid (Deb *et al.*, 1997).

Zinc deficiency in crops is a global phenomenon. In spite of this the role of zinc as one of the many micro-nutrients in stabilizing crop production has not yet been properly appreciated (Deb & Sachder, 1994). Micro-nutrient research has been particularly handicapped because of the smaller concentrations of these nutrients encountered in the soil solution of agricultural soils. One of the way to solve this problem is the use of radioisotopes. Further it was revealed that the use of radioisotopes could help to determine the mechanism of micro-nutrients behavior in the soil.

Zinc deficiency in several soils in Indonesia has also been recognized as shown by several research carried out by Institut Pertanian Bogor and the Center for Soil and Agroclimate Research (Soepardi, 1981; Al-Jubric *et al.*, 1991). In connection with further research of zinc in Indonesia, it might be that the radioisotope $^{65}Zn$ could be use to clarify the behavior of it in soil; so that the need of Zn application could be more accurate.

In this paper the use of $^{65}Zn$ a gamma emitter radioisotope with a half life of 243.6 days for determining several soil characteristics have been reported.

## METHODS

The material and methods where $^{65}Zn$ was used is described a follows. Soils from different locations have been used, namely, Oxisol (Latosol) from Pasar Jumat, South Jakarta; Inceptisol (Regosol) from Bogor, West Java; Histosol (Alluvial) from Pusakanegara, West Java; and Ultisol (Red Yellow Podzolic, RYP) from Batumerta, South Sumatra. The physical and chemical characteristics are presented in Table 1. The soils might not represented the soils deficient in zinc, but the employment of these soils in the experiments are due to their availability in the Centre for the Application of Isotopes and Radiation, Jakarta.

**Table 1. Chemical and physical properties of soil used for experiment I, II, III.**

| | Jakarta Oxisol (Latosol) | Bogor Inceptisol (Regosol) | Pusakanegara Histosol (Alluvial) | Batumerta Ultisol (RYP) |
|---|---|---|---|---|
| pH (1.1) | | | | |
| $H_2O$ | 5.4 | 5.7 | 6.35 | 5.20 |
| KCl | 4.3 | 4.4 | 5.44 | 4.20 |
| Organic-C (%) | | | | |
| Total-N (%) | 1.25 | 1.58 | 3.82 | 1.92 |
| Total-P Bray 1 (ppm) | 0.14 | 0.15 | 0.20 | 0.15 |
| Total-P Olsen (ppm) | - | - | 16.60 | 15.20 |
| Exchangeable base (ml/100g) | | | | |
| Ca | 10.1 | 8.7 | 23.94 | 3.12 |
| Mg | 3.4 | 2.2 | 6.71 | 1.08 |
| K | 0.3 | 0.1 | 0.72 | 0.25 |
| Na | 0.4 | 0.1 | 0.50 | 0.22 |
| C.E.C. | 27 | 21.1 | 33.08 | 12.20 |
| Al 3+ | - | - | 1.06 | 5.99 |
| H+ | - | - | 0.50 | 0.60 |
| Texture | | | | |
| Sand (%) | 0.7 | 7 | 25.90 | 19.17 |
| Silt (%) | 30.3 | 39 | 24.40 | 43.15 |
| Clay (%) | 69.0 | 54 | 49.70 | 37.68 |


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Table 2. Zinc fixation capacity of soils.

| Soils | A | | | | | | | B | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cpm/4ml | | | | cpm | | | cpm/4ml | | | | Cpm | | | | |
| | 1 | 2 | 3 | Total | Average X 12.5 | % $^{65}$Zn recovered | $\bar{x}$ | 1 | 2 | 3 | Total | Average X 12.5 | % $^{65}$Zn recovered (Zn chelate) | $\bar{x}$ | % $^{65}$Zn fixed in soil | $\bar{x}$ |
| Blank | 237 | 238 | 238 | 713 | | | | 227 | 249 | 238 | 714 | - | - | | | |
| Psj 1 | 261 | 295 | 253 | 774 | 250.0 | 1.54 | | 1120 | 1152 | 1132 | 3404 | 11208.3 | 69.22 | | 29.22 | |
| Psj 2 | 262 | 260 | 253 | 775 | 254.2 | 1.57 | 1.56 | 1225 | 1215 | 1206 | 3646 | 12216.7 | 75.46 | 72.34 | 22.97 | 26.1. |
| B-1 | 272 | 260 | 260 | 793 | 329.2 | 2.03 | | 939 | 965 | 971 | 2875 | 9004.2 | 55.62 | | 42.35 | |
| B-2 | 260 | 261 | 260 | 779 | 270.8 | 1.67 | 1.85 | 954 | 955 | 965 | 2874 | 9000.0 | 55.59 | 55.61 | 42.74 | 42.6 |
| PN-1 | 275 | 259 | 266 | 799 | 354.2 | 2.19 | | 942 | 944 | 966 | 2852 | 8908.3 | 55.02 | | 42.79 | |
| PN-2 | 258 | 258 | 254 | 774 | 250.0 | 1.54 | 1.87 | 965 | 970 | 989 | 2924 | 9208.3 | 56.88 | 55.95 | 41.58 | 42.2 |
| Bt-1 | 299 | 262 | 272 | 871 | 654.2 | 4.04 | | 1463 | 1414 | 1507 | 4384 | 15291.7 | 94.45 | | 1.51 | |
| Bt-2 | 282 | 300 | 307 | 866 | 633.3 | 3.91 | 3.98 | 1421 | 1392 | 1499 | 4312 | 14591.7 | 92.60 | 93.53 | 3.49 | 2.50 |
| Standard | | | | | 16204.8 | | | | | | | 16190.0 | | | | |

**Notes :**

- Blank (distilled water , 4 ml) and filtrate (4ml) are counted in a gamma-ray spectrometer (see experiment 1 : procedure) and expressed in counts per minute (cpm), blank each filtrate is count 3 times (1,2,3)
- Standard is an average of several counts : 16325, 16356, 16389, 16495, 16500, 16589 (A).
- Average cpm . $\dfrac{cpm_{filtrate}}{cpm_{standard}} \times 100\%$
- % $^{65}$Zn fixed in soil = 100% - (A+B)%

**Experiment 1: Determination of Zinc Fixation Capacity of Soils**

A. 1. Take 10 g. soil in a conical flask

2. Add 50 microgram labeled Zn through 50 ml of ( 1 ug Zn/ml) $^{65}$Zn labeled standard (1 uCi/mg Zn) $ZnSO_4.7H_2O$
3. Shake for 1 hour and filter with filter paper Whatman No. 40
4. Take 4 ml filtrate and measure $^{65}$Zn (count per minute = cpm) in a gamma- ray spectrometer
5. Measure $^{65}$Zn in 50 ug Zn -standard solution (cpm)
6. Calculate Zn fixation in each soil and express the results in percent.

% Zn-fixed in water in soluble from :

$$\frac{\text{cpm } ^{65}\text{Zn in 50 ml filtrate}}{\text{cpm } ^{65}\text{Zn in 50 ml standard}} \times 100\ \%$$

B. Recovery of fixed Zn in 0.1 N HCl extract :

1. Add 50 ml 0.1 N HCl to each flask, containing the previous soils
2. Mix thoroughly and shake for 2 hours, filter with filter paper Whatmann No. 40
3. Measure $^{65}$Zn (cpm) in 4 ml filtrate and calculate recovery of fixed Zn

% Recovery of Zn (will be available to plants slowly) =

$$\frac{\text{cpm } ^{65}\text{Zn in 50 ml filtrate}}{\text{cpm } ^{65}\text{Zn in 50 ml standard}} \times 100\ \%$$

Percent Zinc fixed in unavailable form :

100 % - (A + B) %

**Experiment 2. Determination of Zinc transformation in submerge condition**

Procedure

1. Take 10 g soil in a 22 ml counting vial
2. Add 10 ml distilled water and 2 ml standard solution.
3. Shake
4. The soils in the vials are left to be submerged for 24 hours, 1 week, and 2 weeks respectively.
5. After each submersion period, the vial are centrifuged for 10 minutes at 3000 rpm.
6. 4 ml filtrate of each soil and 1 ml standard of $^{65}$Zn are counted in a gamma-ray spectrometer and are expressed in count per minute (cpm)

% $^{65}$Zn recovery in solution :

$$\frac{\text{cpm - filtrate in 12 ml}}{\text{cpm - filtrate standard}} \times 100\ \%$$

**Experiment 3. Determination of capacity factor of zinc ( Buffering capacity of zinc) in soils**

Procedure :

1. Take 2, 3, 4, 5, 6 and 8 g soil in 22 ml counting vials.
2. Add 8,5 ml distilled water + 1,5 ml $^{65}Zn$ standard solution
3. Shake for 24 hours in a mechanical shaker
4. Centrifuge for 10 minutes at rate of 3000rpm
5. Run a standard without soil i.e. 1 ml $^{65}Zn$ activity + 9 ml distilled water along with the samples
6. Plot percent $^{65}Zn$ remaining per cc solution (x) against percent of added $^{65}Zn$ adsorbed (y)
   (Method by Elgawhary, S.M., W.L.Lindsay & D. Kamper (1990), Proc. Soil Sci Soc. Am. 34 :66 - 77). For more detailed description see Attachment 1.

## RESULTS AND DISCUSSION

### Zinc Fixation Capacity of Soils

Data obtained from Experiment 1 presented in Table 2 showed that percent $^{65}Zn$ recovered in soluble form are very low, ranging from 1.56% - 3.98%. The highest percentage $^{65}Zn$ recovered was shown by soil from Batumerta (Bt). Further from Table 1 it was shown that, percent of $^{65}Zn$ recovered with 0.1 HCl (Exchangeable + chelated Zn), which would be slowly available to plants, range from 55% to 93% . Here too soil from Batumerta has the highest available Zn (Table 2). While for percentage $^{65}Zn$ fixed in soil, the data ranged from 2% - 42%. From data presented in Table 2, it was shown that soil with high Zn recovery has a low zinc fixation capacity as shown by soil from Batumerta. Thus, it could be pointed out that between soils there are differences in Zn slowly available (exchangeable + chelated Zn) to plants.

This should be taken in consideration in connection with the possibility of Zn-residue of Zn fertilizer applied. It is expected that soils with high exchangeable and chelated Zn are able to make Zn-residue from Zn-fertilizer applied available to plants in due time.

### Zinc Transformation in Submerged Condition

Zinc application to soils in submerged condition showed that even after only 24 hours of submergence, percent $^{65}Zn$ remained in standing water was low, ranging from 0.17% to 2.44% (Table 3). By these data it was demonstrated that more than 88% of Zinc applied has been retained by soil in insoluble from after 24 hours. After 1 week of submergence these values of $^{65}Zn$ remained in standing decrease sharply from 0.44% to 0.18%, and from 2.44% to 0.40% for soils from Pasar Jumat and Batumerta respectively (Table 3).

While for soils from Bogor and Pusakanegara there were slight increases, from 0.17% to 0.23% and 0.18% to 0.29% (Table 3). Further it was shown that after 3 weeks of submergence all the soils showed decrease of % $^{65}Zn$ remaining in standing water up to very small amounts (Table 3). When connected with Zn-fertilizer application, these data indicate that at the time Zn-fertilizer would be applied the plants should already have a develop root system to be able to use immediately the Zn available. Of course this fact need more elaboration where plants have to be included.

Table 3. Zinc transformation in submerged condition.

| Soil | cpm/4ml | | | cpm | | % $^{65}Zn$ recovery in water solution | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | Average Blank | Average X3 | X | $\bar{X}$ |
| | | | | 24 hours of submergence | | | |
| PsJ-1 | 292 | 289 | 268 | 45 | 135 | 0.42 | |
| PsJ-2 | 285 | 255 | 280 | 49 | 146 | 0.45 | 0.44 |
| B-1 | 256 | 250 | 259 | 17 | 52 | 0.16 | |
| B-2 | 259 | 261 | 251 | 19 | 57 | 0.17 | 0.17 |
| PN-1 | 270 | 250 | 251 | 19 | 57 | 0.17 | |
| PN-2 | 260 | 254 | 259 | 20 | 60 | 0.19 | 0.18 |
| Bt-1 | 496 | 505 | 502 | 263 | 789 | 2.44 | |
| Bt-2 | 500 | 498 | 502 | 262 | 786 | 2.43 | 2.44 |
| | | | | 1 week of submergence | | | |
| PsJ-1 | 265 | 257 | 284 | 20 | 60 | 0.20 | |
| PsJ-2 | 265 | 270 | 260 | 16 | 48 | 0.16 | 0.18 |
| B-1 | 256 | 257 | 284 | 17 | 51 | 0.17 | |
| B-2 | 269 | 296 | 266 | 28 | 84 | 0.28 | 0.23 |
| PN-1 | 270 | 299 | 298 | 40 | 120 | 0.40 | |
| PN-2 | 255 | 261 | 284 | 19 | 57 | 0.19 | 0.29 |
| Bt-1 | 295 | 286 | 292 | 42 | 126 | 0.42 | |
| Bt-2 | 290 | 293 | 277 | 38 | 114 | 0.38 | 0.40 |
| | | | | 2 week of submergence | | | |
| PsJ-1 | 252 | 253 | 253 | 3.7 | 11 | 0.04 | |
| PsJ-2 | 258 | 257 | 246 | 4.7 | 14 | 0.05 | 0.05 |
| B-1 | 256 | 254 | 252 | 5.0 | 15 | 0.05 | |
| B-2 | 265 | 250 | 252 | 4.3 | 13 | 0.04 | 0.05 |
| PN-1 | 282 | 280 | 279 | 15 | 45 | 0.15 | |
| PN-2 | 266 | 276 | 250 | 31 | 93 | 0.31 | 0.23 |
| Bt-1 | 253 | 255 | 264 | 5 | 15 | 0.05 | |
| Bt-2 | 273 | 252 | 257 | 12 | 36 | 0.12 | 0.09 |

Notes :

- Blank (4 ml distilled water) and filtrate (4 ml) are counted in a gamma-ray spectrometer (see experiment 2 : procedure) and expressed in count per minutes (cpm), blank for 24 hours of submergence = 238, for 1 and 2 weeks of submergence = 249
- Standard is an average of several counts, for 24 hours = 32380, for 1 and 2 weeks = 29986
- Cpm (average-Blank) : example 24 hours : $\frac{(292 + 289 + 258)}{3} - 238 = 45$
- Cpm (average X 3) : filtrate counted in 4 ml, while the soil was submergence with 12 ml distilled water + $^{65}Zn$ solution :
  % 65Zn recovery = [cpm (average )/cpm standard] x 100%

Table 4. Capacity factor (buffering capacity) of zinc in soils.

| Weight of soil (g) | PASAR JUMAT | | | BOGOR | | | PUSAKANEGERA | | | BATUMARTA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cpm/4ml | a | b | cpm/4ml | a | b | cpm/4ml | a | b | cpm | a | b |
| 2-I | 463.7 | 0.071 | 59.5 | 389 | 0.059 | 59.6 | 200 | 0.025 | 59.9 | 548 | 0.198 | 58.8 |
| 2-II | 495 | 0.076 | 59.5 | 372.5 | 0.052 | 59.6 | 211.5 | 0.027 | 59.9 | 543 | 0.274 | 58.4 |
| 3-I | 268.7 | 0.041 | 39.8 | 307 | 0.027 | 39.8 | 193.5 | 0.017 | 40.0 | 565 | 0.287 | 38.9 |
| 3-II | 271 | 0.042 | 39.8 | 309 | 0.028 | 39.8 | 192.5 | 0.017 | 40.0 | 523 | 0.185 | 39.2 |
| 4-I | 165 | 0.025 | 29.9 | 292 | 0.022 | 23.9 | 211.5 | 0.027 | 29.9 | 466 | 0.156 | 29.5 |
| 4-II | 230 | 0.035 | 29.9 | 285 | 0.019 | 23.9 | 197 | 0.019 | 29.9 | 493 | 0.170 | 29.5 |
| 5-I | 197.5 | 0.030 | 23.0 | 265.5 | 0.012 | 24.0 | 181.5 | 0.011 | 24.0 | 459 | 0.152 | 23.6 |
| 5-II | 175 | 0.027 | 23.4 | 265 | 0.011 | 24.0 | 184 | 0.013 | 24.0 | 457 | 0.152 | 23.6 |
| 6-I | 107.5 | 0.017 | 19.9 | 255.5 | 0.011 | 20.0 | 230.5 | 0.036 | 19.9 | 416 | 0.131 | 19.8 |
| 9-II | 100 | 0.015 | 19.9 | 289.5 | 0.021 | 19.9 | 172 | 0.007 | 20.0 | 387 | 0.115 | 19.8 |
| 8-I | 85 | 0.015 | 15.0 | 281 | 0.017 | 15.0 | 205 | 0.023 | 15.0 | 440 | 0.143 | 14.9 |
| 8-II | 96 | 0.013 | 15.0 | 266 | 0.018 | 15.0 | 202 | 0.022 | 15.0 | 391 | 0.118 | 15.0 |
| Capacity factor of soils | | 714 | | | 1000 | | | 2400 | | | 270 | |

a : $\%^{65}Zn/ml$ (x)
b : $\%^{65}Zn$ absorbed/cc (y)
- blank : 159 cpm, standard (average of 4 counts) = 49120/10 ml

Notes

- For more detailed information see attachment

- Bulk Density (BD) of soil from Pasar Jumat (PsJ), Bogor (B), Pusakanegera (PN) and Batumarta (BT) are 1.28, 1.2 and 1.2 respectively

Example :

- Batumarta = 29 soil
- Filtrated (4 ml) = 548 cpm)
- Cpm for 10 ml = (10/4 x 548) - blank = 389
- $\%^{65}Zn$ in 10 ml = $\frac{389}{\text{Standard}} \times 100\%$

  = $\frac{389}{49120} \times 189 = 1.98$
- $\%^{65}Zn$ in 1 ml = 0.198 (a)
- B.D. = 1.2 Zn absorbed = $\frac{100\% - 1.98\%}{29} \times 1.2\ (BD)$ = 58.8 % (b)

## Capacity Factor of Zinc/Buffering Capacity of Zinc in Soils

From Table 4 after plotting the values of x against values of y, the capacity factor of Zn in soils are : Batumerta (270) < Pasar Jumat (714) < Bogor (1000) < Pusakanegara (2400). According to Deb*, soils with a high capacity factor, has a high capability to hold Zn applied in solid form. What ever Zn applied will be hold in solid form in high quantities for soil with high capacity of Zinc, like soil from Pusakanegara, meaning it would take time to make this Zn applied to be available to plants.

## CONCLUSIONS

From these experiments the conclusions are,

1. $^{65}Zn$ could be used satisfactorily to determine the zinc fixation capacity of soils, Zn remaining in water when there is a submerged condition, and the capacity factor of zinc soils.
2. By using $^{65}Zn$ it could be shown that different soils will have different zinc fixation ability, decrease of Zn available in water at submerged condition after 3 weeks , and different capacity factors.


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