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Synthesis of wheat-atta enriched nano clay polymer composite and evaluation of its effect on soil water properties

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Abstract
In this chapter an attempt has been made to synthesized of Atta-wheat flour enriched Nano Clay polymer Composite and further investigate water absorption pattern of Atta-wheat flour enriched NCPC in distilled water, salt solution, water retention and re-swelling capacity of NCPC added soil. This experiment conducted using different concentration of Atta-wheat flour (1%, 2% and 4%) with 10% NCPC. The results revealed that due to addition of Atta-wheat flourincrease the water absorbance in both distilled and different salt solution ($NaCl_2$, $CaCl_2$ and $AlCl_3$), re-swelling and water retention capacity of soil (Alluvial, Red and Sandy soil). Maximum water absorbance in distilled water and water retention found with 4% Atta-wheat flour and absorbance in salt water found in 2% Atta-wheat flour. The effect of different cationon water absorbance found in following order Na^{+}> Ca^{2+}>Al^{3+}.The maximum water retention by alluvial soil

Keywords: Biopolymer, NCBPC (nano clay bio polymer composite), absorbance

1. Introduction
The biggest challenge faced by agricultural researchers is to produce sufficient quantity and quality of food to full fill the requirement of ever increasing global population and also to maintain the soil health and agro-ecosystem. World's large cropland area under rainfed area. Only 17% of global cropland area under irrigated area and produce 40% food (Doll, 2002 and Pastel, 2000) [2, 6]. So rainfed agriculture occupied a large area but low productivity because of lack of water and low efficiency of resources. To counter the increasing food demand pressure due to increasing population we must need to increase the productivity of rainfed area and may be possible by increasing the water use efficiency. Sixty seven percent of current global water withdrawal is by irrigated agriculture so it accounts the single largest consumer of water (Doll, 2002; Feres and Soriano, 2007) [2]. Superabsorbent polymers play a significant role in rainfed agriculture to increase the water and nutrient use efficiency. Superabsorbent polymers were first developed in 1970s by USDA, for improving the water holding capacity of soils, to promote seed germination and plant growth (Liu and Guo, 2001) [4]. Nanoparticle's (NPs) are those having size in the order of 100 nm or less (Auffan *et al.,* 2009). Superabsorbent polymers (SAP) are three-dimensional cross-linked hydrophilic materials that imbibe a large amount of water or aqueous solution and display a slower water release rate. Owing to their excellent properties, superabsorbent is widely used in many fields such as agriculture, tissue engineering, waste-water treatment and other environmental (Ma, *et al.*, 2015) [5]. In general, superabsorbent has following types as synthetic, semi synthetic and natural polymers. Because of the low toxicity, good water absorbent capacity, and excellent biocompatibility and biodegradability, research on polysaccharide-based natural material superabsorbent is growing (Witono *et al.*, 2015; Wang, 2011), especially the study of starch-based superabsorbent.

2. Role of Biopolymer
- Increase water absorption, water retention in soil.
- Increase nutrient use efficiency.
- Increase soil microorganism due to addition of starch source.
- Bio degradable so it is ecofriendly.

3. Materials and method

Prepiation of nano clay polymer by polymerization acrylic acid along with Atta-wheat flour under controlled condition.
The process and calculation same as used in measurement of equilibrium water absorbency of NCPC in distilled water.

$$Q = \frac{M2-M1}{M1}$$

Where, M1 and M2 are the weight of dry sample and swollen sample, respectively. Q was calculated as grams of water per gram dry hydrogel (g/g).
Water retention behavior in soil

$$WR\% = \frac{Wt-Wi}{Weq-Wi} \times 100$$

Where, WR% = percent water retain.
Wt. = weight at different time.
WI = initial weight.
Weq. = equilibrium weight

Table 1: Treatment detail for experiment

T_1	N+Atta-wheat flourflour (1 %)
T_2	N+Atta-wheat flourflour (2 %)
T_3	N+Atta-wheat flourflour (4 %)
T_4	NCPC (with 10% clay) without starch
Blank	Soil (without NCPC and flour)

N=NCPC (Nano Clay Polymer Composite

4. Results and Discussion

4.1 Water Absorbency

The water absorbency found maximum in T_3 (NCPC + 4%Atta-wheat flour) was 176.4 g/g NCPC. Followed by T_2 (NCPC + 2% Atta-wheat flour) was 170.8 g/g NCPC. The minimum found in T_4(control) was 151.21 g/g NCPC. We found that with increase in concentration of solute the absorbency increases. All treatment performs better than control. It also found that initially the rate of water absorbency was very fast than it decline. During the initial 120 min, the swelling rate was higher than that of later swelling process. As the swelling process continuing, the swelling rate was reduced, and the curves of the swelling rate became flatter and swelling equilibrium could be finished within 1 day. So we concluded that due to addition of Atta-wheat flour it increase the water absorbency of NCPC, it is because of the addition of flour decrease the physical crosslinking degree of NCPC and improve polymeric network structure (Qi *et al*. 2009). So increase water absorbency. Initial higher rate of swelling was due to more available surface area of the composite for water molecule to interact them.

4.2 Re-swelling Capacity

Re-swelling capability of superabsorbent composites was a vital characteristic in the practical application. As shown in Table 2 and 3 the composites still retained approximately 87.5% (T_3) and 86% (T_{10}) of their initial water absorbency after re-swelling 2 times respectively. It could be concluded from the above information that all treatment show good re-swelling capacity. Gao*et, a*l. (2016) reported that composite still retained approximately 65% (WB-g PAA/kaolin), 42% (WB-g-PAA/polygorskite), 47% (WB-g-PAA/ latterite) and 48% (WB-g-PAA/ diatomite), of their initial water absorbency after re-swelling 6 times, respectively.

4.3 Water Absorbency of NCPC in salt solution

The influence of salt concentration and ionic valence to the swelling behavior of superabsorbent polymer were analyzed during the course of investigation. We found the maximum water absorbency with salt concentration 1M in NaCl, $CaCl_2$ and $AlCl_3$ was in T_2 (21.3 g/g)and T_2(13.8 g/g) and T_2 (5.75 g/g) respectively and minimum was T_4 (14.3), T_1 (11.6) and T_1 (5.55 g/g), respectively. With decrease salt concentration increase the absorbency and at the salt concentration 0.01 M the maximum water absorbency in NaCl, $CaCl_2$ and $AlCl_3$ was T_2 (43.9 g/g) and T_3 (36.7 g/g) and T_3(30.6 g/g) respectively, and minimum found was T_4(25.75), T_4 (20.05) and T_4(16.85 g/g), respectively. The trend of water absorbency in different salt are observe as NaCl> $CaCl_2$> $AlCl_3$. So we conclude that with increase in salt concentration decrease the absorbency (Zhang *et al*. 2014) this was because, for ionic hydrogels, the additional cations causing an anion−anion electrostatic repulsion, leading to a reduced osmotic pressure difference between the external solution and the polymer network, resulted in decreased swelling. The addition of flour also increase the absorbency of polymer in salt solution But at high concentration of salt we found the decrease in water absorbency (T_1, in 1m con of $CaCl_2$ and $AlCl_3$ which was low than the control. And also T_3 show poor performance than T_2 in all salts solution). It is explained by both the repulsion between the charged carboxy-methyl groups and the osmotic pressure caused by the cation counter ions due to the increased crosslink density, the water uptake decrease (Fekete *et al.* 2015). We found the effect of valance on absorbency in the following order Na^+>Ca^{2+}>Al^{3+} (Ma *et al.* 2015) [5]. So with increase the valance decrease the water absorbency.

4.4 Water Retention

We conducted the experiment to find out the water retention capacity of NCPC in different type of soil such as Alluvial, Red and Sand. In alluvial soil found highest water retention in T_3 which retain water up to 16 days,(86.8 % after 1day to 0.90% after 16 day)followed by T_2 (81 % after 1day to 1.0% after 15 day) The minimum water absorbency found in Blank (82.69% after 1 day to 0.0% after 12 day) respectively followed by T_4 (93.41% after 1 day to 0.00% after 14 day).In Red soil found highest water retention in T_3 which retain water up to 14 days,(87.5% after 1day to 1.60% after 14 day), followed by T_2 (84.2% after 1day to 0.8% after 13 day). The minimum water absorbency found in Blank (77.73% after 1 day to 0.0% after 11 day), followed by T_{10} (80.00% after 1 day to 0.00% after 12 day).In Sand soil found highest water retention in T_3 which retain water up to 11 days, (85.8 % after 1day to 0.8% after 11 day) followed by T_2 (79.45% after 1day to 1.0% after 10 day). The minimum water absorbency found in Blank (84.69% after 1 day to 0.0% after 6 day) with the followed by T_4 (78.00% after 1 day to 0.00% after 8 day).
So we conclude that the addition of NCPC in soil increases the water retention and the addition of flour in NCPC increase the capacity of NCPC to retain water. It is due to addition of NCPC in soil it make a network structure and bound the soil to make aggregate so soil water retention increase and by addition of flour increase the cross linking so polymeric network made stronger and difficult to remove the water. The water retention in drying was related to hydrogen bond sand Van der Waal's force interaction between water molecules and the superabsorbent. So due to addition of flour the interaction was stronger and the water retention was better (Patra *et al.* 2010). The order of water retention of different

soil was found as follows: Alluvial soil> Red Soil >Sand soil which may be due to inherent difference in textural pattern triggering the variation in clay 7 sand content of the soil, like Alluvial soil contain more clay & microspores when compared to Red soil with higher sand content.

Table 2: Equilibrium Water absorbency of NCPC

Water absorbency (g H_2O/g NCPC)								
Treatment	**15 min**	**30min**	**60min**	**120min**	**240min**	**480min**	**12 hr**	**24 hrs**
T_1	27.3	51.9	95.6	136.6	150.3	154.4	159.9	162.6
T_2	28.7	54.5	100.5	143.5	157.9	162.2	167.9	170.8
T_3	29.6	56.3	103.7	148.2	163.0	167.5	173.4	176.4
T_4	25.4	48.2	88.9	127.0	139.7	143.5	148.6	151.2
SEm	0.5	1.0	1.9	2.7	3.0	3.1	3.2	3.2
SEd	0.7	1.4	2.7	3.8	4.2	4.3	4.5	4.6
CD 5%	1.6	3.0	5.6	8.1	8.9	9.1	9.4	9.6

Table 3: First Re-swelling Water absorbency of NCPC

Water absorbency (g H_2O/g NCPC)								
Treatment	**15min**	**30min**	**60min**	**120min**	**240min**	**8hrs**	**12hrs**	**24hrs**
T_1	26.9	51.1	94.1	134.5	147.9	151.9	154.6	157.3
T_2	27.5	52.3	96.3	137.7	151.4	155.6	158.3	161.1
T_3	28.4	54.1	99.6	142.4	156.6	160.9	163.7	166.6
T_4	26.1	49.6	91.4	130.5	143.6	147.5	150.1	152.7
SEm	0.8	1.6	2.9	4.2	4.6	4.8	4.8	4.9
SEd	1.2	2.2	4.2	6.0	6.6	6.8	6.9	7.0
CD 5%	2.5	4.7	8.7	12.5	13.8	14.1	14.4	14.6

Table 4: Second Re-swelling Water absorbency of NCPC

Water absorbency (g H2O/g NCPC)							
Treatment	**15min**	**30min**	**60min**	**120min**	**240min**	**8hrs**	**12hrs**
T_1	26.9	51.2	75.4	113.3	119.8	128.6	138.6
T_2	27.4	52.0	76.7	115.0	121.9	131.0	141.0
T_3	29.9	56.8	83.7	124.2	133.1	144.0	154.0
T_4	25.7	48.7	71.8	108.6	114.2	122.1	132.1
SEm	0.3	0.6	0.9	1.2	1.5	1.7	2.4
SEd	0.5	0.9	1.3	1.7	2.1	2.4	3.4
CD 5%	1.0	1.9	2.8	3.6	4.4	5.1	7.1

Table 5: Effect of NaCl salt on absorbency of NCPC

Absorbency(g/g NCPC)						
30 min				**60 min**		
Treatment	**1 M**	**0.1 M**	**0.01M**	**1 M**	**0.1 M**	**0.01M**
T_1	13.8	24.9	24.5	15.3	24.8	36.7
T_2	19.8	27.2	36.5	21.3	30.9	43.9
T_3	19.5	25.7	36.0	21.0	28.5	41.7
T_4	12.8	20.0	19.8	14.3	19.8	25.7
SEm	0.6	1.4	1.6	0.2	0.9	0.9
SEd	0.9	2.0	2.3	0.3	1.2	1.3
CD 5%	2.0	4.6	5.1	0.8	2.8	2.9

Table 6: Effect of $CaCl_2$ salt on absorbency of NCPC

Absorbency (g/g NCPC)						
30 min				**60 min**		
Treatment	**1 M**	**0.1 M**	**0.01M**	**1 M**	**0.1 M**	**0.01M**
T_1	10.9	14.0	28.4	11.6	14.0	29.3
T_2	11.3	15.7	29.9	12.6	16.1	30.7
T_3	11.3	17.2	34.4	13.8	18.1	36.7
T_4	10.2	12.6	19.8	11.9	13.0	20.0
SEm	0.3	0.5	0.8	0.3	0.7	1.4
SEd	0.4	0.7	1.2	0.4	1.0	2.0
CD 5%	1.0	1.6	2.8	1.0	2.4	4.5

Table 7: Effect of $AlCl_3$ salt on absorbency of NCPC

Absorbency(g/g NCPC)			
30 min			
Treatment	**1 M**	**0.1 M**	**0.01M**
T_1	5.55	12.00	27.55
T_2	5.75	12.35	30.15
T_3	5.80	12.70	30.60
T_4	7.60	9.10	16.85
SEm	0.341	0.901	1.372
SEd	0.483	1.274	1.941
CD 5%	1.076	2.839	4.324

Table 8: Water Retention Capacity of Alluvial Soil with NCPC

Water Retention (%)																
Treatment	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**	**6 day**	**7 day**	**8 day**	**9 day**	**10 day**	**11 day**	**12 day**	**13 day**	**14 day**	**15 day**	**16 day**
T_1	80.5	71.5	63.9	56.2	44.3	41.2	35.3	28.6	23.0	15.6	10.0	6.0	3.0	0.7	0.0	0.0
T_2	81.0	73.7	64.0	57.5	46.6	42.0	35.1	29.4	25.3	18.9	14.4	10.7	4.6	2.6	1.0	0.0
T_3	86.8	80.1	71.4	65.4	54.4	47.9	37.4	33.4	30.2	20.5	16.4	11.4	5.9	4.4	2.4	0.9
T_4	93.4	82.0	75.3	61.0	48.0	41.6	35.5	29.8	19.4	11.7	6.3	2.9	0.8	0.0	0.0	0.0
Blank	82.6	68.8	68.8	58.2	39.5	34.0	26.3	20.9	15.5	8.8	3.7	0.0	0.0	0.0	0.0	0.0
SEm	1.7	1.9	1.8	1.7	1.9	2.2	2.2	2.0	0.9	0.9	0.9	0.9	0.6	0.8	0.1	0.1
SEd	2.4	2.7	2.5	2.5	2.7	3.2	3.2	2.8	1.3	1.4	1.3	1.2	0.8	1.1	0.2	0.1
CD 5%	5.3	6.0	5.7	5.6	6.0	7.1	7.0	6.3	2.9	3.0	3.0	2.8	1.9	2.5	0.5	0.3

Table 9: Water Retention Capacity of Red Soil with NCPC

Water Retention (%)														
Treatment	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**	**6 day**	**7 day**	**8 day**	**9 day**	**10 day**	**11 day**	**12 day**	**13 day**	**14 day**
T_1	80.9	71.2	61.9	52.6	40.5	34.4	20.6	17.3	11.3	6.3	3.8	0.5	0.0	0.0
T_2	84.2	74.1	64.5	54.8	42.2	35.8	25.1	21.1	15.1	10.1	6.0	2.8	0.8	0.0
T_3	87.5	77.0	66.9	56.9	43.8	37.2	29.8	25.0	19.0	14.0	8.4	5.1	2.5	1.6
T_4	80.0	70.4	61.2	52.0	40.0	34.0	20.4	17.1	11.1	6.1	3.7	0.0	0.0	0.0
Blank	77.7	68.4	59.5	50.5	38.9	33.1	18.2	13.4	7.4	2.4	0.0	0.0	0.0	0.0
SEm	1.8	1.5	1.3	1.1	0.9	0.7	1.2	1.0	1.0	1.0	0.6	0.6	0.3	0.1
SEd	2.5	2.2	1.9	1.6	1.2	1.0	1.7	1.4	1.4	1.4	0.8	0.9	0.4	0.1
CD 5%	5.6	4.9	4.3	3.6	2.8	2.4	3.9	3.2	3.2	3.2	1.9	2.0	1.0	0.3

Table 10: Water Retention Capacity of Sand Soil with NCPC

Water Retention (%)											
Treatment	**1 day**	**2 day**	**3 day**	**4 day**	**5 day**	**6 day**	**7 day**	**8 day**	**9 day**	**10 day**	**11 day**
T_1	72.5	58.1	46.5	32.5	12.5	7.0	3.9	1.7	0.0	0.0	0.0
T_2	79.4	60.9	47.3	33.5	15.5	10.7	5.1	3.0	1.5	1.0	0.0
T_3	85.8	70.2	56.7	37.0	17.8	13.4	9.1	5.3	2.6	2.1	0.8
T_4	78.1	61.9	44.8	35.9	14.5	7.2	1.8	0.0	0.0	0.0	0.0
Blank	84.6	55.6	41.9	20.4	3.9	0.0	0.0	0.0	0.0	0.0	0.0
SEm	2.2	2.7	2.4	3.0	3.9	1.4	0.9	0.4	0.5	0.1	0.1
SEd	3.2	3.8	3.5	4.2	5.5	1.9	1.2	0.6	0.8	0.2	0.1
CD 5%	7.0	8.5	7.7	9.4	12.3	4.3	2.8	1.4	1.8	0.5	0.3

5. Conclusion
In the present experiment Atta-wheat flourenriched NCPC was successfully synthesized. The findings showed that addition of Atta-wheat flour with NCPC increase the water behavior of NCPC like water absorbency and water retention capacity increases in distilled as well as in salt water. Increasing the concentration of flour showed increasing the distilled water absorbance and water retention. Addition of 4% flour show maximum results. In salt solution 2% flour concentration show maximum absorbency. In salt solution the valences showed their effect. Higher the valance of cation lowers the absorption. All treatment show better than control (NCPC 10%). Due to addition of Atta-wheat flour it show biodegradable properties show it has environment friendly.

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