4. RESULTS AND DISCUSSION

4.1. Production of Biogas and organic manure:

The production of biogas and natural organic manure from cow dung and sewage sludge throughout anaerobic digestion in one batch operated Chinese and Indian model digesters (200 L digested volume) were investigated under greenhouse conditions. The organic wastes were fermented for 70 days, the daily biogas generation and cumulative gas production throughout the fermentation periods are illustrated in Figures (3, 4, 5). The total biogas yield and its components of CH_4 and Co_2 are tabulated in Table (4). The changes of chemical components of organic wastes under anaerobic fermentation in two model biogas digesters are given in Table (5). The initial and final total and volatile solids and their losses are presented in Table (6). The production rates of biogas and methane from volatile solids added and consumed in Chinese and Indian type digester are given in Table (7).

The organic wastes were different in the starting period for biogas generation according to the type of organic material and digester model. Sewage sludge started biogas production within the first day of fermentation period for both digesters (Fig. 3). The initial biogas production from cow dung were at 14 and 18 days for Chinese and Indian type

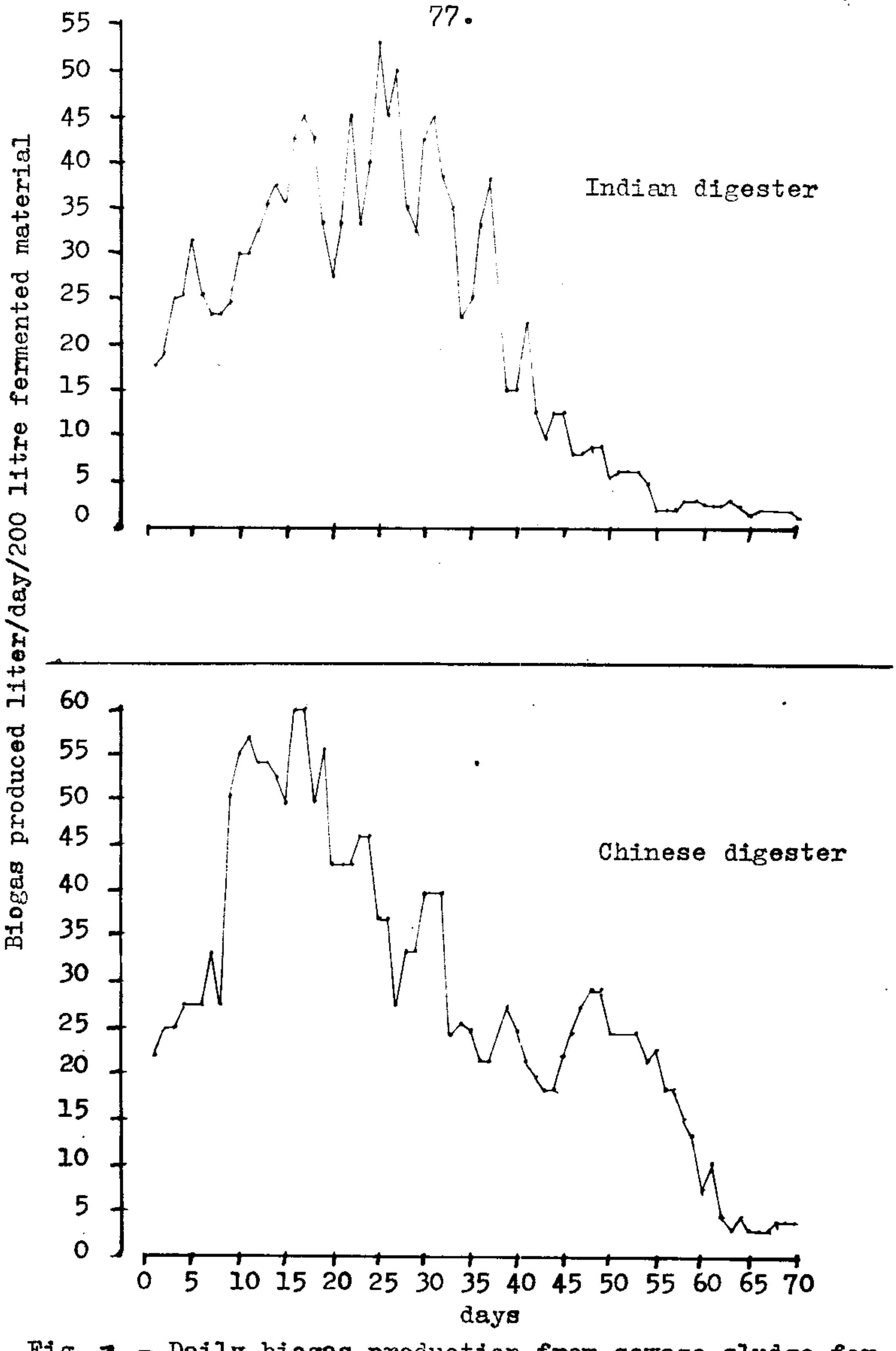

Fig. 3 - Daily biogas production from sewage sludge for 70 days in Chinese and Indian type digesters.

digester, respectively (Fig.4). These results are in accordance with Alaa-El-Din et al. (1984) who found that sewage sludge, septic tanks cleanings and their mixtures with garbage produce biogas within the first day while fresh garbage moistened with water needs a lag period of 9-23 days. This might be due to the previous anaerobic fermentation in septic tanks. Also, Alaa-El-Din et al., (1982) mentioned that agricultural residues delayed in producing biogas when fermented under the same conditions. Sewage sludge is known to have the proper mixtures of microflora necessary for both acid and methane fermentation stages. The numbers of the organisms are usually very high (Hobson and Shaw, 1973; Chengdu, 1979; Velsen, 1979 ; and Wise et al. 1981).

The daily production of biogas showed fluctuations in all organic residues and digesters. The digesters recorded gradual increase in biogas production to reach a peak differently according to the kind of raw organic material and digester model. Thereafter, the productivity began to decrease. Sewage sludge showed a peak of biogas production at the 16th days (60 L/biogas/day/200 L fermented material) in the Chinese digester. On the other hand, cow dung recorded a peak after 30 days of fermentation

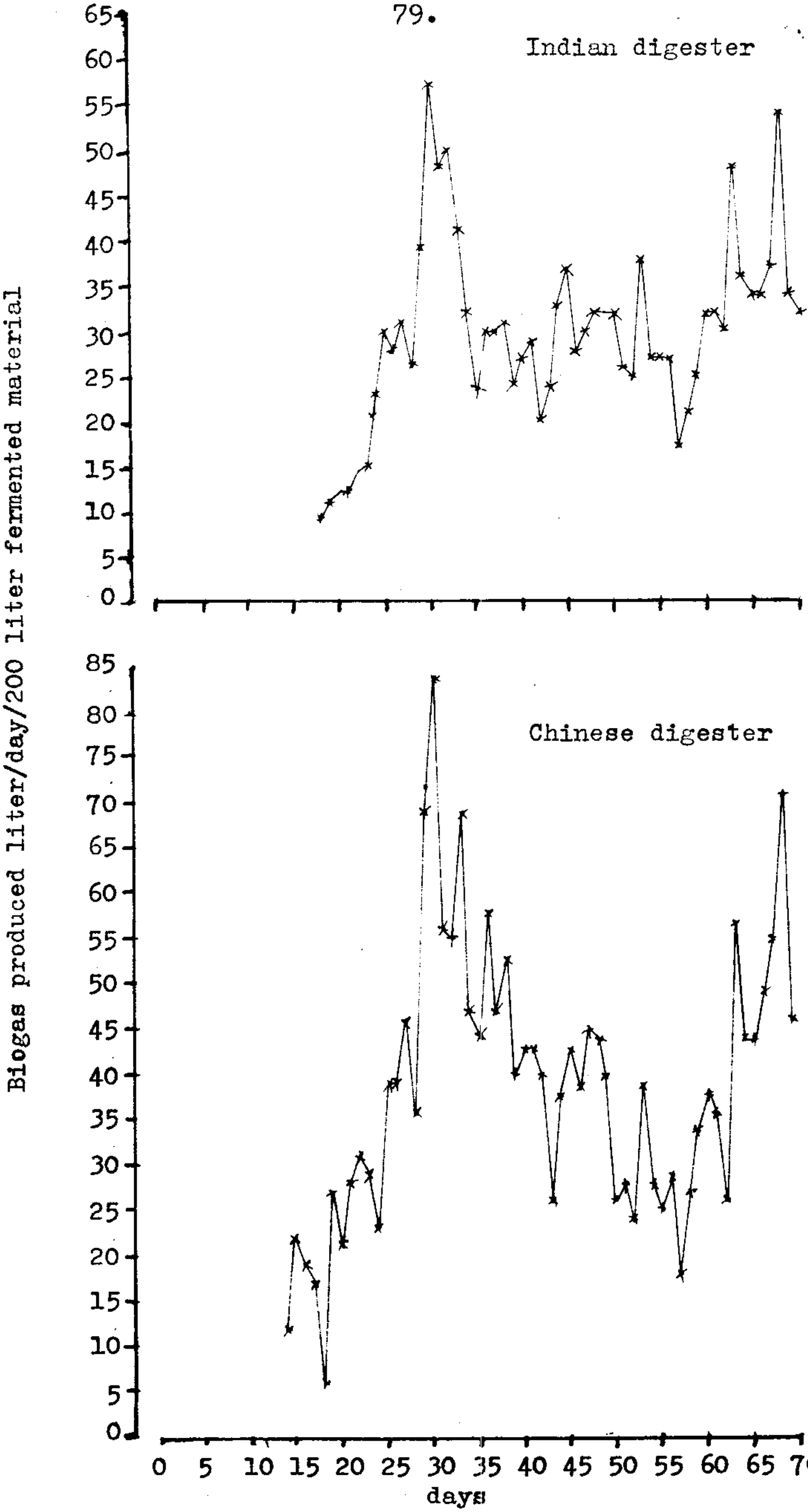

Fig. 4 - Daily biogas production from cow dung in Chinese and indian type digesters for 70 days.

period in both Chinese and Indian type digester. The maximum of biogas production was 84 and 57 L biogas/day/ 200 L fermented cow dung in Chinese and Indian model, respectively. These fluctuations were most probably due to the temperature changes occuring in the greenhouse where digesters were kept above the ground. Kugelman and McCarty (1965) and Pyle (1978) reported that a sudden change exceeding 3°C will effect biogas production. In this concern, Aly (1985) concluded that the daily biogas production was fluctuated as a result of temperature changes in the digester. He added that the biogas generation is affected by the type of organic residues and design of the digester.

The cumulative figures of biogas generation differed according to the type of waste and the design of digesters. In Chinese digester (Fig. 5) cow dung produced higher value of biogas production (2154 L) followed by sewage sludge (2018 L). The Indian digester showed lower values for both residues, where, on the contrary of the Chinese type, sewage sludge gave gas production of 1681 L which is more than cow dung (1547 L).

The composition of biogas contents of CH_4 and Co_2 (Table 4) did not show apparent differences between

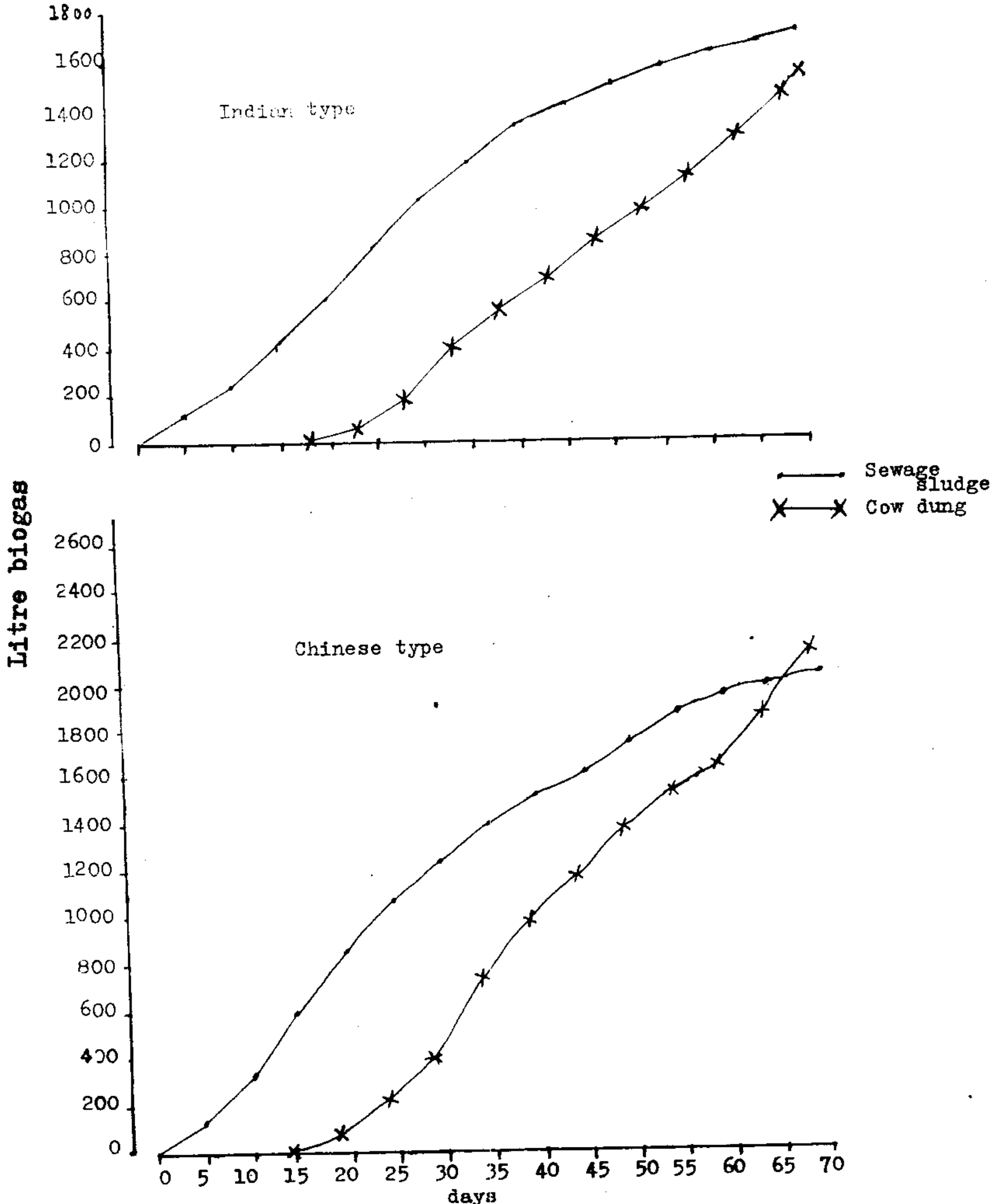

Fig. 5 - Cumulative biogas production from 200 litre fermented materials in Chinese and Indian type digesters for 70 days

Table 4 - Total biogas, methan and CO_2 produced during fermentation of cow dung and sewage sludge in Chinese and Indian type digesters for 70 days.

Organic wastes	Biogas produced L/200 L fermented material							
	Chinese digester				Indian digester			
	Total biogas yield	Methane		CO_2	Total biogas yield	Methane		CO_2
		Liter	%			Liter	%	
Cow dung	2154	1417.3	65.8	689.3	1547	1016.4	65.7	510.5
Sewage sludge	2018	1412.6	70.0	565.0	1681	1186.8	70.6	333.0

Chinese and Indian digesters for the same fermented material. On the contrary, the gas quality was different between sewage sludge and cow dung. The average of CH_4 content ranged between 70-70.6% of sewage sludge and 65.8-65.7% of cow dung. In earlier study, El-Husseini (1983) found that sewage sludge produced higher methane content (77-78%) while biogas of paunch waste contained only 62 to 65% methane. The high methane content of sewage sludge could be attributed to the large numbers of methanogenic bacteria recorded for these residue (Hobson and Show, 1973; and Chengdu, 1979).

The losses in both total and volatile solids were higher in sewage sludge than cow dung in the two digesters types. However, the figures of the percentage loss were very close in Chinese and Indian digesters showing slight increase in volatile solids loss in the former and in total solids in the later (Table 6). This phenomena could be attributed to the larger population of active microbes responsible for acid formation and methane production in sewage sludge than cow dung. The volatile solids losses from different organic wastes were recorded by many workers (Velsen, 1977; Nasr 1980; Alaa-El-Din et al., 1984 and Aly, 1985) who reported that the VS losses ranged between

Table 5 - Changes of some chemical components during biomethanization of cow dung and sewage sludge in Chinese and Indian type digesters for 70 days.

Chemical components	Cow dung				Sewage sludge			
	Chinese digester		Indian digester		Chinese digester		Indian digester	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Total solids, %	8.24	7.31	8.56	7.69	3.047	2.043	3.092	2.054
Volatile solids,* %	68.21	57.12	68.31	59.07	68.63	44.94	64.49	46.04
Organic carbon, %	39.56	33.13	39.62	34.27	39.81	26.06	37.40	26.70
Total nitrogen, %	1.659	1.808	1.655	1.839	2.135	2.340	2.107	2.512
Ammoniacal nitrogen, ppm	84	98	105	110	84	206	85	233

* On the basis of dry total solids.

few per cent and up to more than 90% of VS added depending on the system of digestion, the type of residues, the amendment with starter, the incubation time and temperature.

The loss of total nitrogen (TN) during biogas generation from sewage sludge was 26.5% in Chinese digester followed by Indian digester 20.8% (Table 6). Cow dung showed the same trend where the losses were 6 and 2.6% for Chinese and Indian designs, respectively. Volatilization of ammonia specially later in the digestion period when its concentration in the fermentation liquid reached its maximum is expected to be the major source of losses in the total nitrogen. Alaa-El-Din et al. (1984) recorded 8-28% loss of TN but the loss was higher in Indian digester than Chinese which is contradicting with the results obtained in this investigation. However, Aly (1985) who have been working in the same laboratory and using the same residues reported higher loss of TN in Chinese than Indian digester which is the same results obtained in our work.

The organic wastes exerted increasing amounts of ammoniacal nitrogen (NH_4-N) reaching the maximum value after 28 days in the two digesters fed by sewage sludge and then able 6 - Initial and final contents of total and volatile solids, total nitrogen and their losses during biomethanization of cow dung and sewage sludge in Chinese and Indian type digester for 70 days.

hemical omponents	Cow dung						Sewage sludge					
	Chinese			Indian			Chinese			Indian		
	Initial	Final	% losses	Initial	Final	% losses	Initial	Final	% losses	Initial	Final	% losses
otal solids g added/ igester	16.48	14.62	11.3	17.12	14.98	12.5	6.094	4.086	32.95	6.184	4.108	33.57
olatile solids g added/ igester	11.241	8.422	25.0	11.693	8.994	23.0	4.183	1.837	56.08	3.988	1.892	52.56
otal nitrogen added/ igester	273.4	257	6	283	275.4	2.6	130.106	95.612	26.51	130.296	103.193	20.80

decreased to values higher than the initial ones (Fig. 6). In case of cow dung the peaks of high values were recorded at the 7th and 21st days for Indian and Chinese digesters, respectively. The increase of NH_4-N could be attributed to the ammonification of organic nitrogen compounds to form ammonia at a rate higher than the assimilation of ammonia by the growing fermenting microorganisms early in the digestion period. Later, NH_4-N might be consumed increasingly for production of bacterial cell biomass, a process which increased by time throughout the fermentation period besides the loss by volatilization. McCarty (1964) and Chengdue (1979) reported that the toxicity effect of ammonia ranged between 1500-3000 ppm. In this study the ammonia concentration ranged between 84-345 ppm.

The production rates of flammable biogas and methane are estimated to evaluate the efficiency of biogas yield. The results were estimated as liter of gas produced from each unit weight of VS added or consumed (Table 7). The rates of biogas production were high in Chinese digester more than the Indian type digester. The efficiency of conversion of VS consumed to biogas varied according to the material digested and type of fermenter. The Chinese

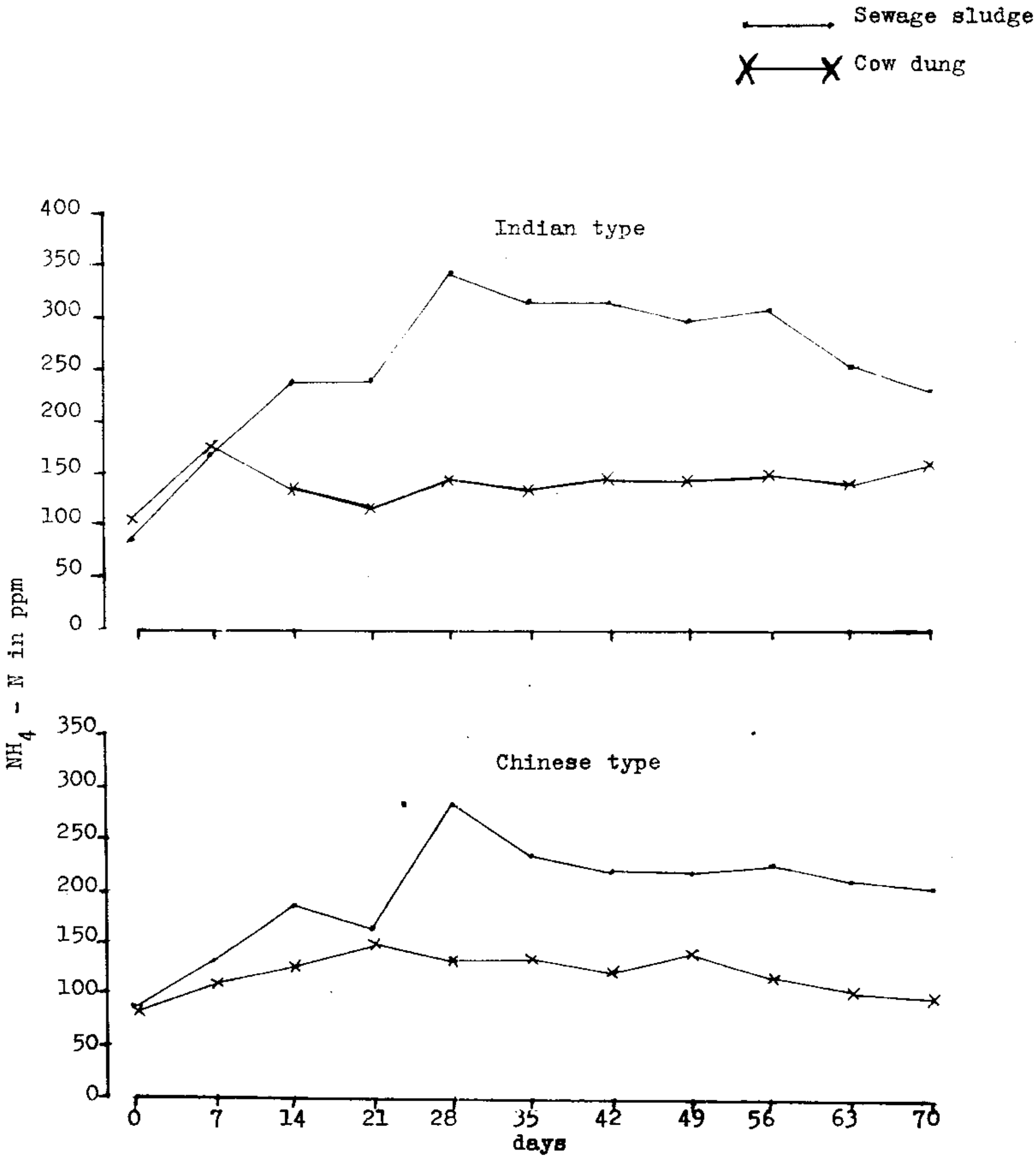

Fig. 6 - Changes of NH_4-N during femrnetation of cow dung and sewage sludge for biogas production.

Table 7 - Biogas and methane production per kg of volatile solids added or consumed in Chinese and Indian biogas digester for 70 days.

Organic wastes	Biogas and methane produced							
	Liter/kg VS added				Liter / kg VS consumed			
	Chinese digester		Indian digester		Chinese digester		Indian digester	
	Biogas	Methane	Biogas	Methane	Biogas	Methane	Biogas	Methane
Cow dung	191.7	126.2	132.3	87.0	764.1	502.8	574.0	377.1
Sewage sludge	482.4	337.7	421.5	297.6	860.1	602.1	802.0	566.2

digester gave high production of biogas and methane for both sewage sludge and cow dung. The degree of conversion of VS were high for sewage sludge than cow dung. The average value of biogas production from sewage sludge were 482.5 and 421.5 L/kg VS added for Chinese and Indian digesters, respectively, while these results were 191.7 and 132.3 for cow dung in Chinese and Indian type digester, respectively. On the other hand, the rates of biogas production were 860.1 and 802.1 L/kg vs consumed for sewage sludge in Chinese and Indian type digesters, respectively. Cow dung recorded lowest value for rate of biogas production, where 764.1 and 574.0 L/kg VS consumed in Chinese and Indian digesters, respectively. The efficiency of biogas digesters was reported by other authors. Aly (1985) reported that the productivity of biogas (L biogas/kg VS added) differed according to type of residue fermented and the design of digester. He mentioned, that the Chinese type digester was more efficient than the Indian one. Alaa-El-Din (1984) noted that the biogas productivity were 0.05-0.10 V/V for Indian and Chinese digesters, respectively. Liu and Chen (1981), Chengdu (1979), Sathianathan (1975) and Singh (1972) reported that the efficiency of the digester subjected to fluctuations according to the temperature and the feeding rate.

It can be concluded that the Chinese type of digesters was more efficient in the anaerobic digestion of organic residues, since it produced almost the same quantity of organic manure as the Indian type while it produced more amounts of biogas than the Indian digester.

4.2. Effect of organic manures on the density of micro-organisms:

4.2.1. Total bacterial count:

Data in Table (8) illustrated by Fig. (7) show that the density of bacteria in the alluvial soil collected from Moshtohor ranged between 18 and 79 millions per one gram dry soil.

The addition of different kinds of organic manure significantly increased the total bacterial counts. This increase appeared in all treatments allover the experimental time. However, the biogas manure resulting from the anaerobic digestion of cow dung and sewage sludge apparently increased the total bacterial count more than the traditional organic manures i.e. farmyard manure and poudrette. In this respect, the digested cow dung manure showed higher counts than digested sewage sludge manure. Also the total bacterial count was higher in the soil receiving farmyard manure than poudrette. It seems that the organic manures orginating from the sanitary refuses, i.e. digested sewage sludge and poudrette contain considerable quantities of trace elements which inhibit the microbial activities in soil, (Tabatabai, 1977; Daif and Beusichem, 1981; Brookes and McGrath, 1984 and Brookes et al., 1984). It was clearly noticed that the activity of bacteria was enhanced when the alluvial soil was treated by different

Table 8 – Total colony counts of bacteria in alluvial and sandy soils treated by different organic manures.

Counts x 10^6/g dry soil

Periods (day)	Alluvial Soil					Sandy soil				
	Control	Traditional organic manures		Digested organic manures (biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm yard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)
0	59	85	77	194	175	19	41	41	67	48
15	79	168	163	331	219	19	54	53	98	86
30	68	232	211	369	298	13	69	61	108	104
60	18	53	52	72	53	13	35	20	42	35
90	43	78	83	116	82	22	37	35	52	30
120	25	73	56	83	64	16	23	19	21	32
160	25	65	85	84	90	10	18	14	18	18
Average	46	108	104	179	141	16	40	37	58	51

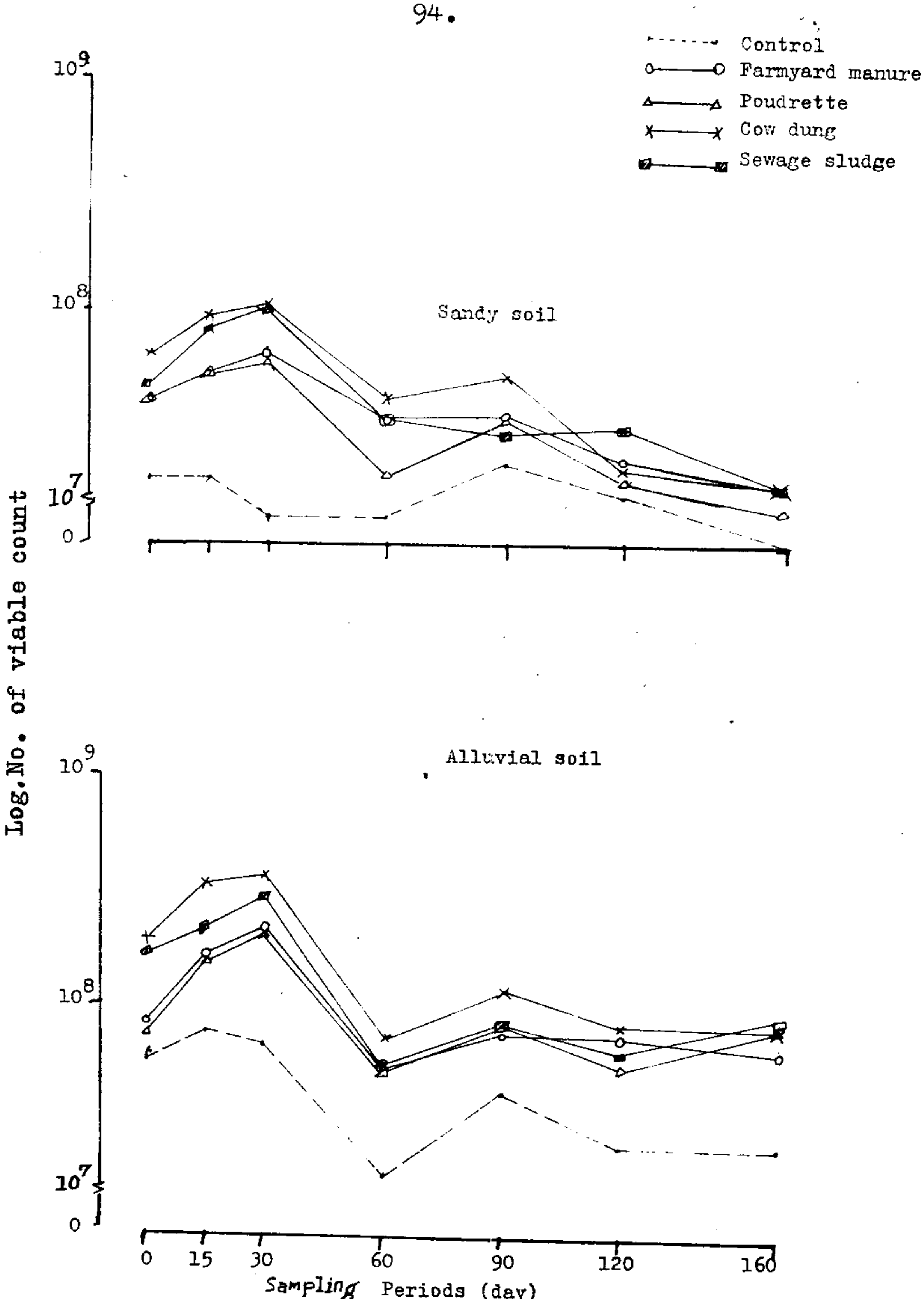

Fig. 7 - Changes in total colony counts of bacteria in soils treated by different organic manures.

organic manures, since the counts gradually increased till 30 days after manuring. The bacterial counts apparently decreased 60 days after manuring, indicating the exhaustion of one or more of the essential nutrients. Thereafter slight increase in the total colony counts of bacteria was observed indicating the proliferation of the endogenous population on the dead microbial cell. However, the mentioned attitude was nearly the same in all the kinds of organic manures used.

Earlier investigators stated the inhancement of soil bacteria when treated with different organic manures which is in accordance with the results obtained in this investigation. Omran (1979), Badran (1983), Sharma et al. (1983) and Filip and Muller (1984), mentioned that the incorporation of sewage sludge, farmyard manure, sewage effluent and fermentation residues in soil increased the total bacterial counts, however the magnitude of increase depended greatly on the type of organic supplements. Zohdy and Badr-El-Din (1983a) stated that farmyard meanure was more effective than digested slurry.

Table (8) and Fig. (7) show that the total bacterial count in the sandy soil collected from south of Tahreer Province, Beheira Governorate is clearly lower than alluvial soil, since it ranged between 10 and 22 millions per one gram dry soil. The effect of manuring the sandy soil in increasing the colony counts of bacteria was more apparent than the alluvial soil indicating the importance of enriching the organic matter content in soils of the arid region. When comparing the effect of the different organic manures on the bacterial count, the same attitude in alluvial soil was also observed in sandy soil. The digested cow dung manure showed the highest densities followed by sewage sludge then farmyard manure and poudrette. Also the counts increased gradually after manuring for 30 days and then decreased in the sample collected on the 60th day. The bacterial population in the sandy soil slightly increased, thereafter using the dead microbial protein.

Saber (1966) stated that the application of raw sewage effluent, decanted sewage effluent or dried sludge increased total bacterial counts and the increase in the dried sludge treatment was more pronounced in the sandy soil, which is the same results obtained in this investigation. Zohdy and Badr-El-Din (1983a) and Zohdy et al. (1984b) found that the addition of compost, farmyard manure, digested slurry, to the virgin sandy soil build up its microbial population. They found that digested slurry and farmyard manure have the most stimulative effect on the bacterial counts followed by urea and sludge.

4.2.2. Actinomycetes:

The densities of actinomycetes appearing on the plate counts were clearly enhanced by the addition of different organic manures to alluvial soil (Table 9, Fig. 8). The digested cow dung residues showed the highest counts, while the other 3 manures used showed almost the same level which is lower than the cow dung. It is clear that the colony counts increased in the samples collected on the 15th day in both control and manured pots. This can be attributed to the activity and proliferation of actinomycetes following the watering of soil at the beginning of the experiment. This activity lasted for 30 days in the case of the digested cow dung treatment, while in the other three treatments, the counts gradually decreased, thereafter till the end of the experimental period due to the gradual exhaustion of the nutrients essential for microbial growth.

The effect of manuring on stimulating the growth of actinomycetes was more pronounced in sandy soil (Table 9, Fig. 8), since the counts were doubled several times in treated pots than control. The biogas manure showed higher counts than traditional organic manures, cow dung residues was more effective in this respect. On the other hand poudrette enhanced actinomycetes growth than farmyard manure.

Table 9 - Total colony counts of actinomycetes in alluvial and sandy soils treated by different organic manures.

Counts x 10^5/g dry soil

Periods (day)	Alluvial Soil					Sandy soil				
	Control	Traditional organic manures		Digested organic manures (biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farmyard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm yard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)
0	14	38	44	62	41	9	12	19	36	21
15	120	160	178	230	167	18	21	19	36	23
30	99	137	137	367	130	38	62	71	70	68
60	70	79	85	98	82	17	44	61	93	50
90	53	63	76	85	62	16	38	48	51	53
120	42	44	48	62	49	15	19	20	45	35
160	35	51	55	72	56	12	16	20	36	21
Average	62	102	111	173	112	23	39	45	71	52

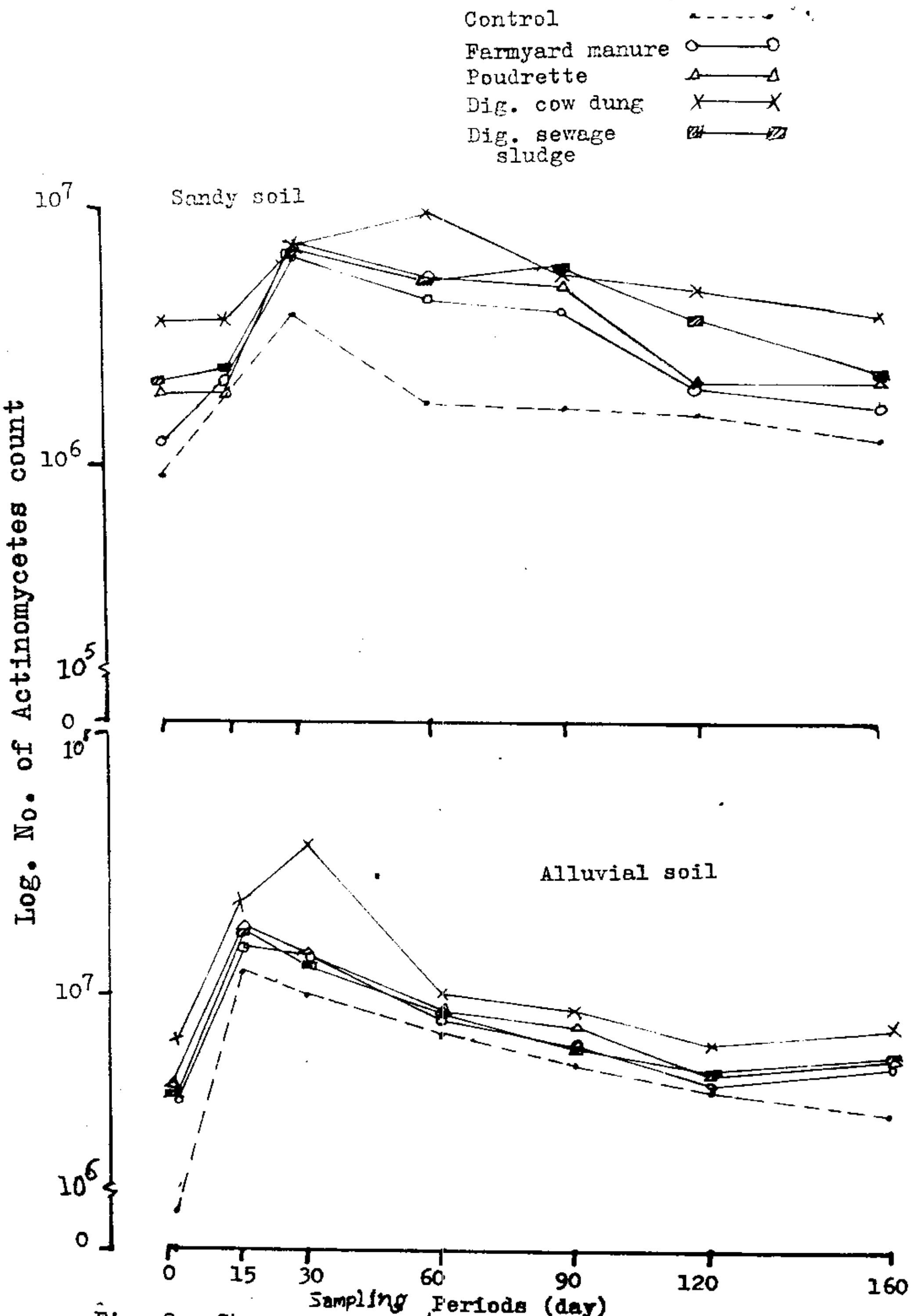

Fig. 8 - Changes in total colony counts of actinomycetes in soils treated by different organic manures.

The actinomycetes showed a 15 days lag period to begin their activity after the addition of the different manures except in the case of the FYM. After this period the counts showed a peak on the 30th day which lasted for another 30 days in the case of the cow dung only. The other three treatments gradually decreased till the end of the experimental period where the counts reached almost their level at the commencement.

Earlier investigators reported that different organic manures enhanced the activities of actinomycetes when added to both alluvial and sandy soil which is the same results appeared in this investigation (Ibrahim 1964, Taha et al. 1966; Hashem 1980; Sharma et al., 1983 and Rao & Vankateswarlu, 1983).

On the other hand, the superiority of the digested organic manures in increasing actinomycetes count assured the results obtained by (Filip and Muller, 1984).

4.2.3. Fungi:

It appears from the data in Table (10) illustrated by Fig. (9), that the counts of fungi appearing on the counting plates were in the order of several tens of thousand per one gram of alluvial soil and several thousands per one gram of sandy soil which is the same levels

Table 10- Total colony counts of Fungi in alluvial and sandy soils treated by different organic manures.

Counts x 10^3/g dry soil

Periods (day)	Alluvial Soil					Sandy soil				
	Control	Traditional organic manures		Digested organic manures (biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm yard manure	Poudrette	Cow dung (DCD)	Sewage sludge
0	13	24	19	19	28	3	6	3	12	12
15	34	129	50	122	154	3	32	34	42	125
30	26	176	204	260	283	15	104	139	177	183
60	14	69	70	105	148	4	27	39	37	60
90	15	24	25	27	23	7	19	18	32	30
120	18	21	16	22	21	3	14	14	21	28
160	19	27	16	26	25	2	6	5	12	16
Average	20	68	58	83	98	6	30	36	48	65

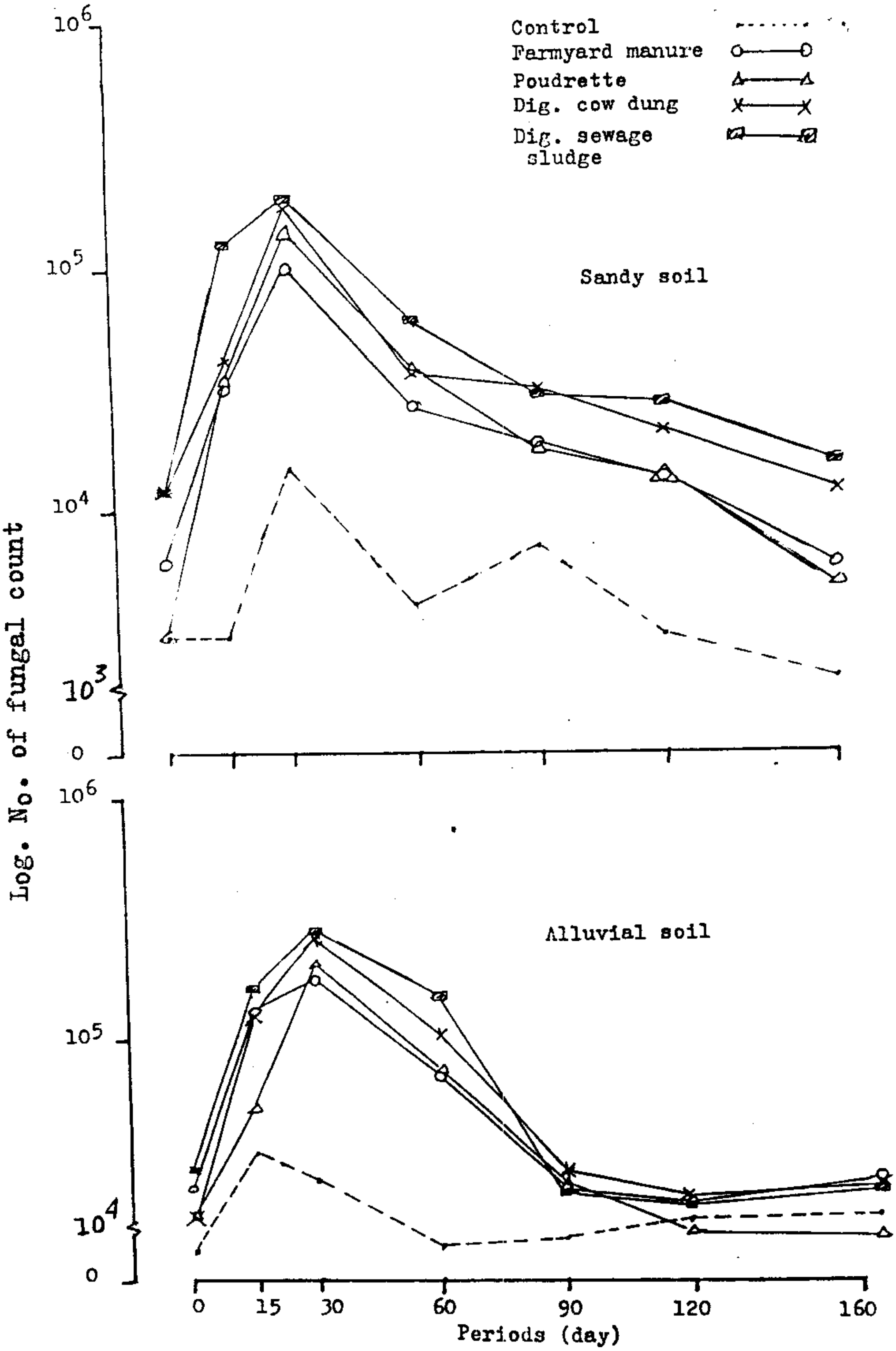

Fig. 9 - Changes in total colony counts of fungi in soils treated by different organic manures.

reported in earlier investigations, (Badran, 1983; Zohdy et al., 1984b).

The application of different organic manures to alluvial soil, clearly promoted the counts of fungi to show a peak 30 days after manuring. The counts gradually decreased thereafter to reach the counts at the beginning of the experiment on the 90th day samples in all treatments. The fungi counts were almost stable at this level to the end of the experiment. The same trend observed in the case of total bacterial count and actinomycetes count concerning the superiority of biogas manure than traditional organic manures in enhancing the microbial growth was also observed in the fungal count. However, the digested sewage sludge was more effective in the proliferation of fungi than digested cow dung, on the contrary of the effect on the bacteria and the actinomycetes.

The stimulating effect of organic manuring on the counts of fungi in alluvial soil was clearly noted by Nilson (1957), Saber (1966), Omran (1979) and Filip and Muller, (1984), who indicated that the soil amended with different organic manures e.g., sewage effluent, dried sewage, animal manures and fermentation residues, produced a high number of fungi than unamended soils, but after different periods from application the number fluctuated and was depending on the type of manure used.

Since the sandy soil is usually poor in the nutrients supplementation, it was quite expected that the addition of such organic manures would result in vigorous growth of fungi (Table 10, Fig. 9). The fungal counts on the 15th day increased by 10.6, 11.3, 14, 41.6 times the control for the FYM, poudrette, cow dung and sewage sludge treatments, respectively. Regarding, the aforementioned comparison, it is clear that the digested sewage sludge was the most effective manure followed by the digested cow dung then the poudrette and FYM. This was true for all the samples collected all over the experimental periods. The fungal counts showed the highest growth on the 30th day followed by gradual reduction to the end of the experimental period. However, the counts never lowered to the level of the initial sample or to the level of the control. This can be attributed to the proliferation of fungi on the expence of the dead microbial protein. It was experimentally reported in this investigation (Tables 18, 19) that the total nitrogen content of the soil increased in the later samples of the soil.

The same results were obtained by Zohdy & Badr-El-Din (1983a) and Zohdy et al. (1984b) who found that the addition of organic manures to the virgin sandy soils stimulated its fungal population, they added that digested spent slurry, FYM, air dried slurry were more effective than urea, silt + slurry, bottom manure and untreated soil.

4.2.4. Aerobic cellulose decomposers:

Table (11) illustrated by Fig. (10) shows that the growth of aerobic cellulose decomposers was enhanced by the addition of organic manures to the alluvial soil. Again the digested cow dung showed the highest effect followed by digested sewage sludge, while the traditional organic manures (FYM and poudrette) showed nearly the same level of promoting which is lower than biogas manure. The highest counts were reported 15 days after application followed by gradual decrease for 4 months. However, the last sample collected on 160 days after application showed slight increase in the counts of aerobic cellulose decomposers indicating their growth on the dead microbial cells.

On manuring the sandy soils, the same effect was observed concerning a rapid increase in the counts of aerobic cellulose decomposers for 15 days after which a steep degradation was observed till the 60th day . The counts at this period were nearly on the same level of the initial sample, but they continued the decrease till the end of the experimental period. The two digested organic manures showed nearly the same level of aerobic cellulose decomposers which is somewhat higher than the level of the pots

Table 11- Total counts of the aerobic cellulose decomposers in alluvial and sandy soils treated by different organic manures.

Counts x 10^3/g dry soil

Periods (day)	Alluvial Soil					Sandy soil				
	Control	Traditional organic manures		Digested organic manures (biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm yard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)
0	13	36	34	48	44	3	11	16	19	19
15	110	178	149	483	256	27	131	99	182	179
30	69	97	121	144	134	12	65	46	89	75
60	47	93	86	236	118	18	25	14	18	21
90	40	68	63	124	169	6	14	10	14	16
120	40	31	11	77	24	2	3	5	4	4
160	25	56	51	101	98	2	5	3	5	6
Average	50	80	74	174	121	10	37	28	48	46

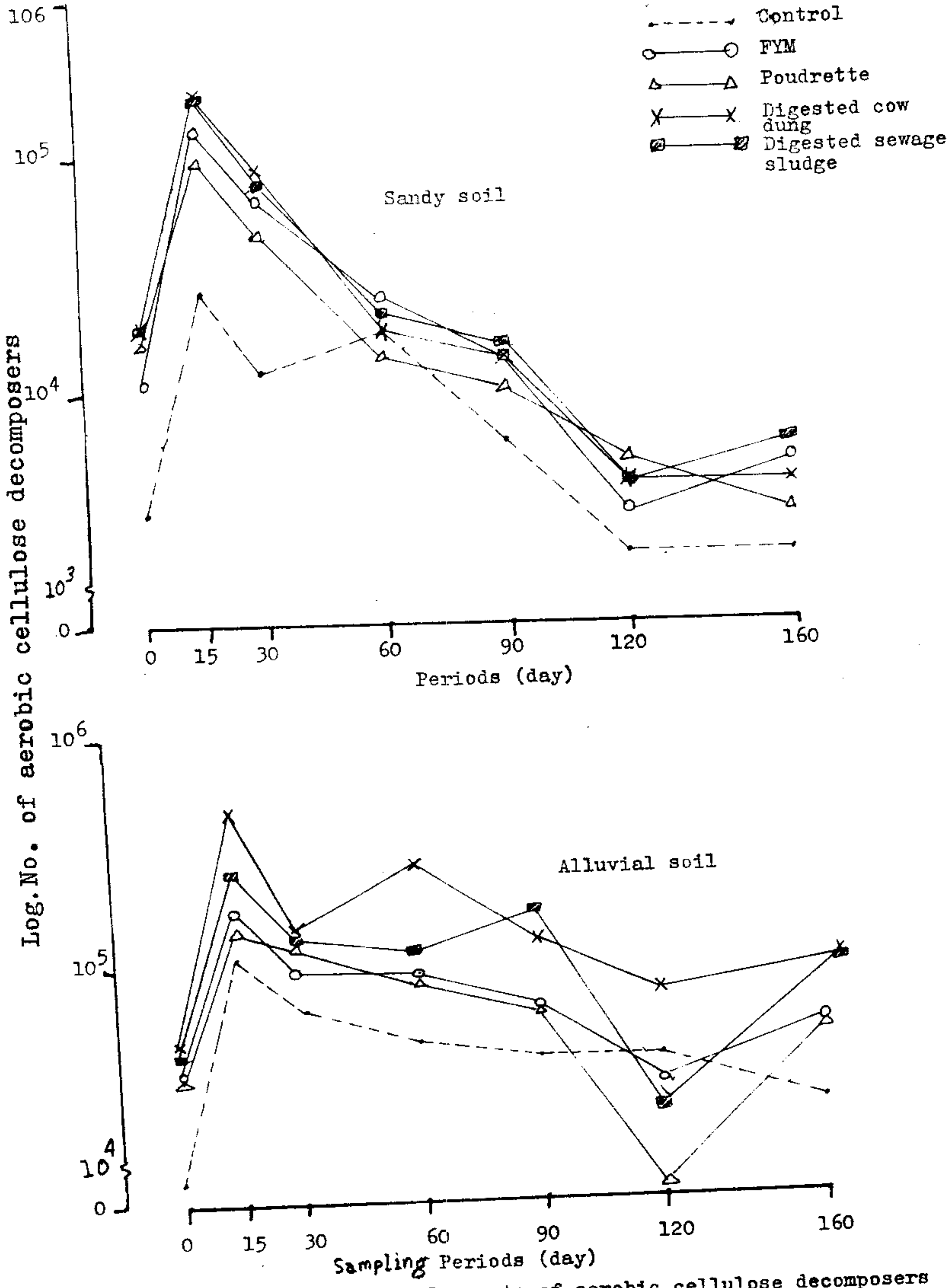

Fig. 10 - Changes in total counts of aerobic cellulose decomposers in soils treated by different organic manures.

treated by traditional organic manure. The FYM encouraged the growth of aerobic cellulose decomposers than poudrette. The results stated above was previously observed by several investigators (Zakharov & Sergeeva, 1957 and Daraselya, 1960). Taha et al. (1966), stated that FYM treatment gave higher count of the aerobic cellulose decomposers than (N, NP, NPK) treatments. This is due to that such organisms depend mainly in their nutrition on cellulose. Also Saber (1966), reported that application of raw sewage effluent, decanted sewage effluent or dried sludge increased aerobic cellulose deoomposers. However, the increase in the dried sludge treatment was more pronounced in the sandy soil.

Generally speaking, organic manuring enhanced the activity of aerobic cellulose decomposers as reported by Hashem (1980) and Badran (1983). Concerning sandy soil, Saber (1966), Zohdy and Badr-El-Din (1983a) and Zohdy et al. (1984b) stated that the addition of organic manures to the virgin sandy soil stimulated the aerobic cellulose decomposers. They found that digested sludge, spent slurry, and compost were more effective than urea, FYM and effluent in stimulating and increasing the number of aerobic cellulose decomposers.

4.2.5. Anaerobic cellulose decomposers:

The anaerobic cellulose decomposers population in alluvial soil was in the order of few thousands per one gram in the control which is the ordinary level in such soils (Table 12 and Fig. 11). The samples collected right after the addition of organic manures showed higher figures than control indicating that these manures contain a fairly high population of anaerobic cellulose decomposers. The anaerobically digested manures showed greatly higher densities than the traditional organic manures. This was quite expected since the anaerobic conditions in the fermentor would encourage the growth of anaerobic microorganisms. This phenomenon lasted to the end of the experiment. However, the counts sharply decreased thereafter for almost one month. This can be deduced to the aerobic conditions in the experimental pots since the moisture content ranged between 33 and 34 per cent all over the experimental period. There was apparent fluctuations in the densities of anaerobic cellulose decomposers in the sample collected two months after manuring till the end of the experimental period. These ups and downs may be a result of the variation in oxygen tension in the micro environment and the competation between anaerobic and aerobic groups of microorganisms for essential nutrients.

Table (12) and Fig. (11) show that the counts of anaerobic cellulose decomposers in the control of the sandy soil was 250 per gram in the initial sample which is fairly

Table 12 - Total counts of the anaerobic cellulose decomposers in alluvial and sandy soils treated by different organic manures.

Counts x 10^2/g dry soil

Periods (day)	Alluvial Soil: Control: Soil without organic manures	Alluvial Soil: Traditional organic manures: Farm-yard manure	Alluvial Soil: Traditional organic manures: Poudrette	Alluvial Soil: Digested organic manures (biogas manures): Cow dung (DCD)	Alluvial Soil: Digested organic manures (biogas manures): Sewage sludge (DSS)	Sandy soil: Control: Soil without organic manures	Sandy soil: Traditional organic manures: Farm yard manure	Sandy soil: Traditional organic manures: Poudrette	Sandy soil: Digested organic manures (biogas manures): Cow dung (DCD)	Sandy soil: Digested organic manures (biogas manures): Sewage sludge (DSS)
0	82	142	127	354	204	2.5	18.1	26.4	195	230
15	43	51	68	126	150	5.1	16	17.2	71	141
30	56	84	95	111	130	1.4	13	18.4	48	28
60	40	78	79	140	99	2.3	5.3	4.0	9	10
90	37	33	40	70	61	2.6	2.5	2.6	4.1	10
120	43	96	89	107	112	5.3	6.5	4.5	8.7	14
160	42	62	60	82	74	2.2	2.9	3.8	6.8	6
Average	49	78	80	142	119	3.0	9.2	11.0	49.0	62.7

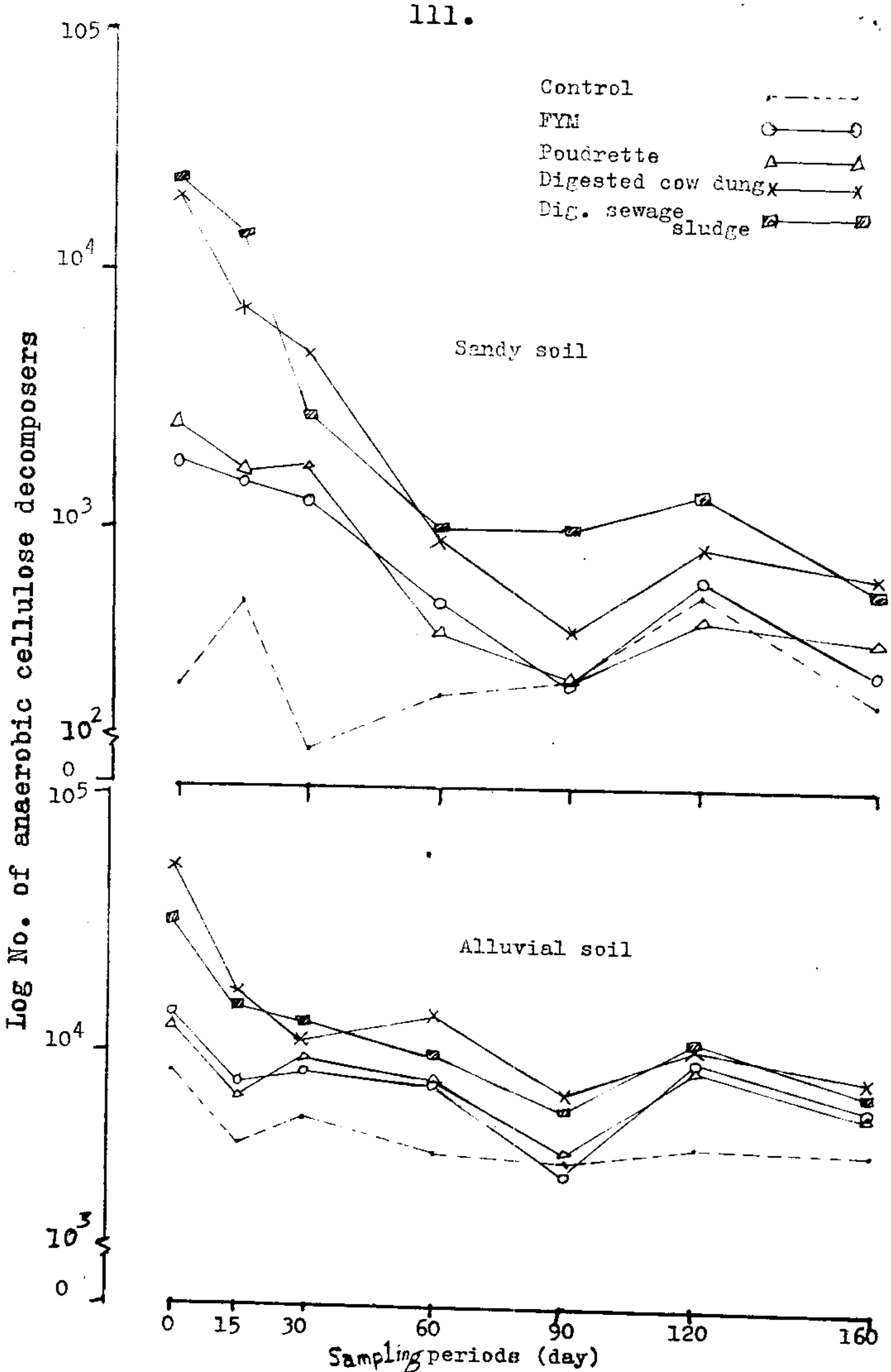

Fig. 11 - Changes in total counts of anaerobic cellulose decomposers in soils treated by different organic manures.

suitable for the good aeration of this type of soil. The pots of sandy soil which were manured showed higher densities of anaerobic cellulose decomposers than control in the samples taken at the beginning of the experiment but still clearly lower than the corresponding treatments in the alluvial soil. The soil treated with digested organic manures i.e. cow dung and sewage sludge showed greatly higher counts than that treated with farmyard manure or poudrette. This was very clear in the initial samples but also true in all samples till the end of the experiment. The digested sewage sludge showed higher counts than cow dung allover the experiment except the sample collected 30 days after manuring where the cow dung treatment was superior. On the other hand, the sandy soil treated with poudrette contained higher densities of anaerobic cellulose decomposers than farmyard manure.

The anaerobic cellulose decomposers in the sandy soil treated with biogas manures followed the same trend observed in the alluvial soil concerning the apparent reduction in counts till the samples collected two months after application. This reduction was followed by moderate fluctuation till the end of the experiment. In the case of farmyard manure and poudrette the counts slightly decreased for one month, then apparent reduction was observed till 90 days from application followed by deep fluctuation.

4.2.6. Coliform group:

The count of coliform group appearing on the McConkey's bile salts agar medium inoculated by alluvial soil was 290 colony per one gram soil of untreated soil (Table 13 and Fig. 12). The natural source of the coliform bacteria in cultivated soil in Egypt is manuring by Balady organic manure which contains the excretes of the farm animals. The initial samples of soil treated with organic manures contained higher counts than control. The poudrette and digested sewage sludge showed 200 per cent increase than control while farmyard manure and digested cow dung showed 90 and 45 percent increase, respectively. This was expected since the origin of both poudrette and digested sewage sludge is the human excretes. The densities of coliform group increased in all treatments including control for 30 days but the growth was more pronounced in manured soils than control. The increase was not proportional to the initial counts indicating that the proliferation of this group of bacteria correlated with the special conditions of each pot. The counts degraded from the 60 days samples and thereafter till the coliform bacteria disappeared completely.

Table 13 - Total colony counts of coliform group in alluvial and sandy soils treated by different organic manures.

Counts x 10^1/g dry soil

Periods (day)	Alluvial Soil					Sandy soil				
	Control	Traditional organic manures		Digested organic manures (biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farmyard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm yard manure	Poudrette	Cow dung (DCD)	Sewage sludge (DSS)
0	29	55	87	42	89	4	14	21	5	18
15	72	99	946	520	378	15	23	84	19	40
30	100	535	942	453	783	13	77	81	22	17
60	20	48	438	32	66	-	5	14	4	2
90	8	11	14	7	15	-	-	3	-	-
120	-	-	12	-	10	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-
Average	65	107	349	151	193	5	17	22	8	11

-: not detected

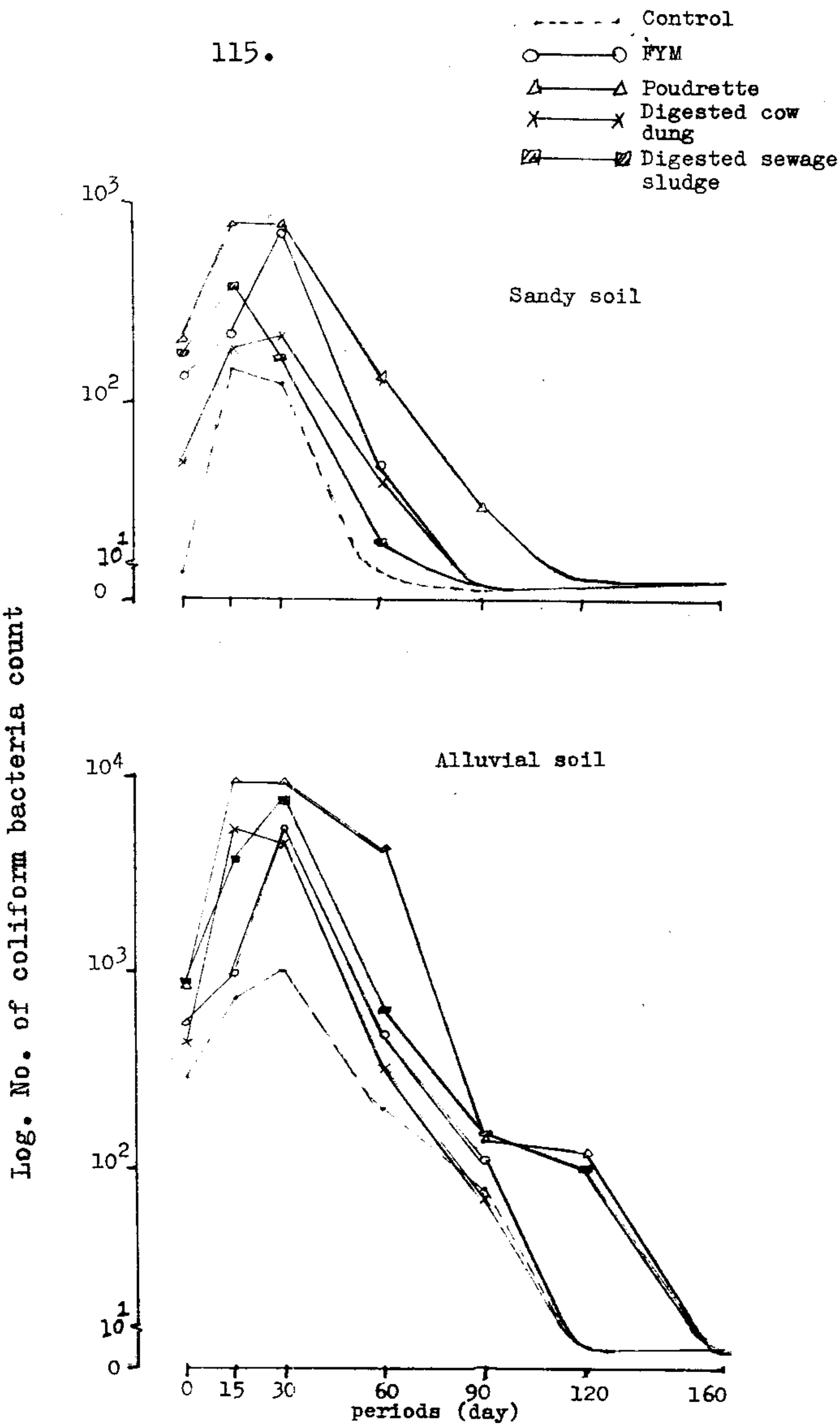

Fig. 12 - Changes in total colony counts of coliform group in soils treated by different organic manures.

The sandy soil obtained from the south Tahreer Province was found to contain only 40 coliform bacteria per one gram of untreated soil which is much less than the alluvial soil. The source of this bacteria is also the manuring with organic fertilizers containing animal excrets. The addition of the used organic manures in this investigation increased the number of coliform bacteria in the initial samples. The poudrette and digested sewage sludge showed higher counts than digested cow dung and Farmyard manure which is the same trend in alluvial soil. The coliform group slightly increased in counts till 30 days from application then decreased thereafter till it completely disappeared in different periods for different treatments.
Earlier investigations revealed that soils contain few numbers of coliform bacteria. For example, Geldereich et al. (1962) found that most soil samples from 26 states and countries show less than 2 feacal coliforms per gram of soil. They observed marked increase in coliforms in polluted soils such as locations recently flooded with domestic sewage. Nothing was found in the literature concerning the fate of coliform bacteria in soils under organic manuring.

4.2.7. Salmonella and Shigella:

Strains of Salmonella species or Shigella species were not detected on the count plates of the control of alluvial and sandy soils. Also the soils treated with the two biogas manures did not show any colonies of Salmonella or Shigella on the counting plates. When the soils were manured by poudrette the initial sample showed 70 and 40 microbes per one gram in alluvial and sandy soils, respectively. The samples collected 15 days after the addition of poudrette contained 220 and 150 colonies per one gram of alluvial and sandy soils, respectively, Table, 14.

The samples taken thereafter till the end of the experiment didn't show any Salmonella or Shigella. Although the farmyard manure treated soils showed no colonies in the initial samples. There were found 15 and 6 colonies of Salmonella and Shigella on the plate counts of 1/10 dilution arizing to 150 and 60 microbes per one gram of alluvial and sandy soil, respectively, in the samples taken 15 days after application. The samples taken thereaftet didn't show any microbes of Salmonella or Shigella.

The aforementioned results are in favour of the suggestion that the anaerobic digestion of organic residues, specially that of domestic or human origin, would result in destroying the pathogenic microorganisms. This was clear since the

Table 14 - Total colony counts of pathogenic microorganism (Salmonella and Shigella) in alluvial and sandy soils treated by different organic manures (counts x 10^1/g dry soil)

Periods (days)	Alluvial Soil					Sandy Soil				
	Control	Traditional organic manures		Digested organic manures (Biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)
0	-	-	7	-	-	-	-	4	-	-
15	-	15	22	-	-	-	6	15	-	-
30	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-
120	-	-	-	-	-	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-
Average	-	2.14	4.14	-	-	-	0.86	2.7	-	-

- : not detected.

soils treated by digested manures via biogas technology were free of Salmonella and Shigella while those treated by traditional manures contained considerable numbers of these pathogenic bacteria.

4.3. Enzymatic activities:

4.3.1. Dehydrogenase: (DHA)

Table (15) and Fig. (13) show the dehydrogenase activity of soil microorganisms in alluvial soil. In control, the activity increased rapdily for 3 days than decreased gradually till 60 days after the irrigation of the soil. The increase of dehydrogenase activity reflex the growth and proliferation of soil microorganisms following the moistening of the soil. Peterson (1967) reported a slight increase in dehydrogenase activity in moist soil during the first few days. The gradually decrease thereafter indicates lessened activity, although the counts of different groups of soil microorganisms showed apparent increase in this period.

The control soil samples collected from the 60th day and

Table 15 - Dehydrogenase activity in alluvial and sandysoil treated by different organic manures.

UL·H/100 g oven dry soil/24 hour

Periods (day)	Alluvial soil					Sandy soil				
	Cont-rol	Traditional organic manures		Digested organic manures		Cont-rol	Traditional organic manures		Digested organic manures	
		FYM	Poud-rette	Cow dung	Sewage sludge		FYM	Poud-rette	Cow dung	Sewage sludge
0	2533	3437	2954	3612	3964	882	1664	1564	1969	1460
1	2581	3742	3282	4394	3457	1154	2103	1840	2565	2627
3	3540	6088	5460	6907	5432	1725	3386	3261	4334	3782
7	3316	5481	5210	6017	4865	2193	3667	3572	4438	4014
15	1753	2673	2662	3519	2375	866	1494	1016	2099	1380
30	1290	2083	1829	2283	1860	767	1162	1138	1330	1405
60	684	1174	784	1285	1400	604	645	663	768	759
90	731	794	696	1012	817	562	547	947	1054	956
120	552	682	668	720	554	400	481	464	557	574
160	501	561	572	643	549	88	123	184	181	220
Average	1748	2671	2411	3093	2527	924	1527	1465	1930	1718

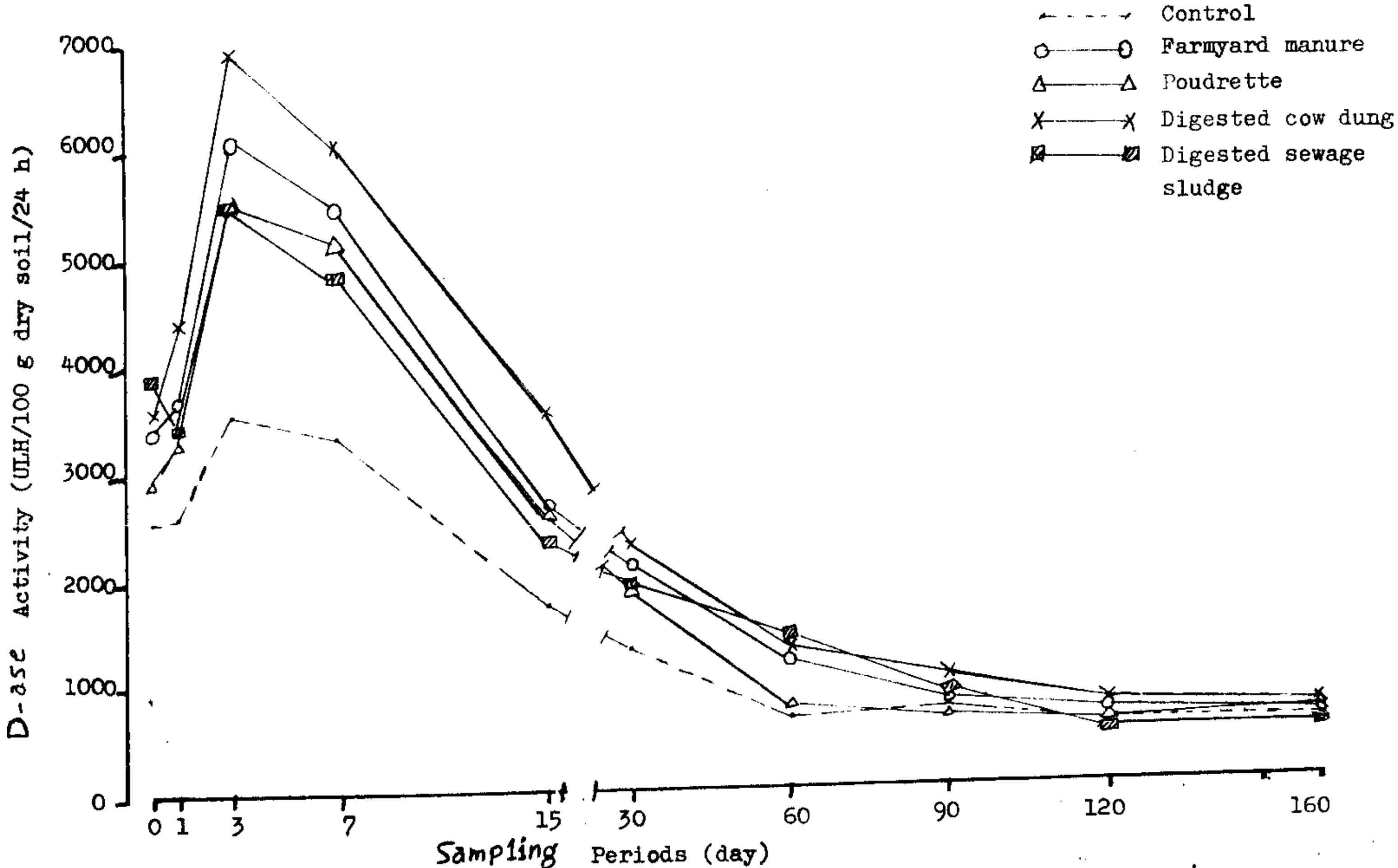

Fig. 13 - Dehydrogenase activity in alluvial soil treated by different organic manures.

thereafter showed almost stable level of dehydrognase activity. Casida et al. (1964) observed that in the absence of added nutrients and moisture the dehydrogenase activity was fairly constant regardless of fluctuations in microbial numbers. The same attitude was observed in the alluvial soil treated with different organic manures, although the figures of dehydrogenase activity were apparently higher than control either in the initial sample or in all the following samples. This stimulation of dehydrogenase in treated samples coincided with the high densities of soil microorganisms in the same treatments. The digested cow dung showed the highest activity of dehydrogenase followed by farmyard manure, poudrette, while digested sewage sludge showed the lowest figures. These results are in accordance with those of Ambrozova (1970), Franz (1973), Boguslawski et al. (1977) & El-Shinnawi et al. (1982) who reported the increase in dehydrogenase activity with increasing organic matter content of the soil and with manuring the soil.

The dehydrogenase activity in sandy soil (Table 15, Fig. 14) was generally lower than alluvial soil in both control and treated soil. The initial samples of treated pots showed apparently high activity of the enzyme than control. When the soil was irrigated, the soil micro-

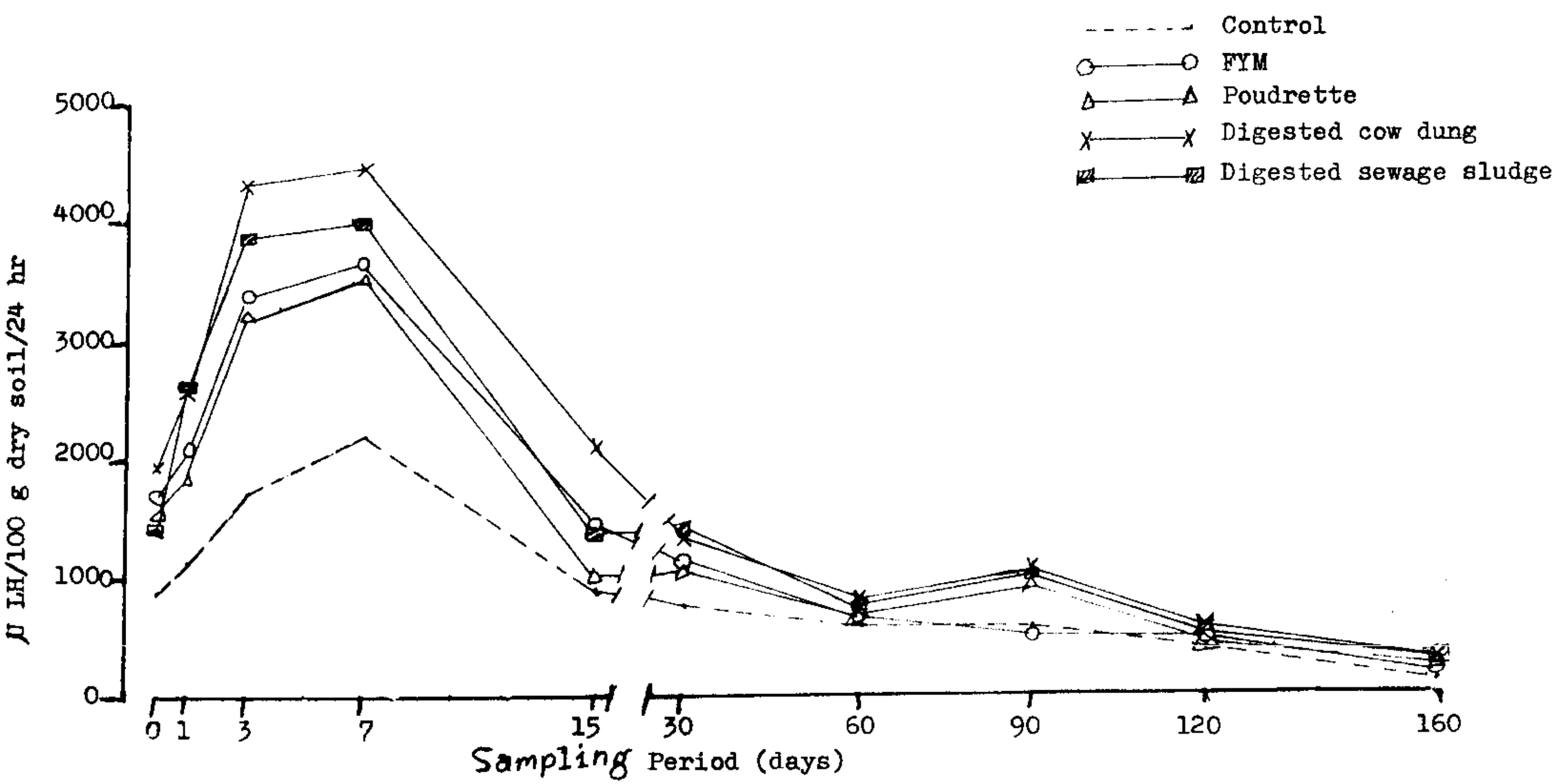

Fig. 14 - Dehydrogenase activity in sandy soil treated by different organic manures

organisms proliferated showing a high peak of dehydrogenase activity in the period of 3 to 7 days followed by a sharp decrease till the 15th day. Casida et al. (1964) stated that the dehydrogenase activity increased with the rapid multiplication of gram negative bacteria in presence of added nutrients and decreased when the metabolic activity of these bacteria slackened. From the 30th day and thereafter the differences between the used organic manures in dehydrogenase activity level was very narrow and very close to its level in the control. The biogas manures were more effective than the traditional organic manures in enhancing the microbial activity when their dehydrogenase activity is considered as a measure. The digested cow dung promoted the DHA than digested sewage sludge and the farmyard manure than poudrette. These results are in accordance with the data obtained from the counts of the studied bacterial group especially the total count, total actinomycetes and total fungi in sandy soil. It was suggested that the sewage sludge and poudrette might contain considerable amounts of heavy metals which lessened their stimulatory effect than digested cow dung and farmyard manure. Tabatabai (1977) mentioned that most sludge samples disposed on soils contain large quantities of various trace elements. Ras'kova et al. (1983)

stated that cadmium and lead reduce the dehydrogenation of organic compounds and hydrogen peroxide.

4.3.2. Phosphatase (Nuclease):

The initial samples of alluvial soil showed that the addition of organic manures favoured the phosphatase activity to reach 200, 184, 206 and 200% of that of control when FYM, poudrette, digested cow dung and sewage sludge, respectively, were added to the soil (Table 16 and Fig. 15). This stimulation is likely to occur since the organic manures already contain vast population of proliferating microorganisms. One day after application the phosphatase activity revealed sharp depression in manured soil while the control showed accelerated activity. The values of the released organic phosphorus decreased to about 50% of the initial sample. It is clear that this depression was a result of the inhibition happened to the microorganisms when added to the soil, a new environment where they need some time to adapt. When the lag period came to an end again the bio-organic catalyst restored its activity to exceed that of control on the third day. The phosphatase activity continued to be vigorously stimulated to reach a peak in the period 7 to 15 days in all treatments except digested cow dung and control where the peak extended to 30 days. The catalytic reaction was inhibited thereafter

Table 16 - Phosphatase activity in alluvial and sandy soil treated by different organic manures.

mg inorganic phosphorus released/100 g dry soil 105°C/24h

Periods (day)	Alluvial soil					Sandy soil				
	Cont-rol	Traditional organic manures		Digested organic manures		Cont-rol	Traditional organic manures		Digested organic manures	
		FYM	Poud-rette	Cow dung	Sewage sludge		FYM	Poud-rette	Cow dung	Sewage sludge
0	18	36	33	37	36	17	25	23	30	19
1	22	16	20	25	30	12	19	19	22	18
3	20	34	27	38	38	18	28	21	35	24
7	40	59	50	63	74	17	22	20	29	22
15	40	62	62	69	77	27	37	32	43	36
30	40	45	58	72	66	17	27	27	34	28
60	8	17	15	17	17	11	16	14	18	15
90	11	17	17	19	19	17	21	20	24	21
120	12	21	14	23	20	7	15	12	15	14
160	10	13	12	14	18	8	11	12	15	13
Average	22.1	32.0	30.8	37.7	39.5	15.1	22.1	20.0	26.5	21.0

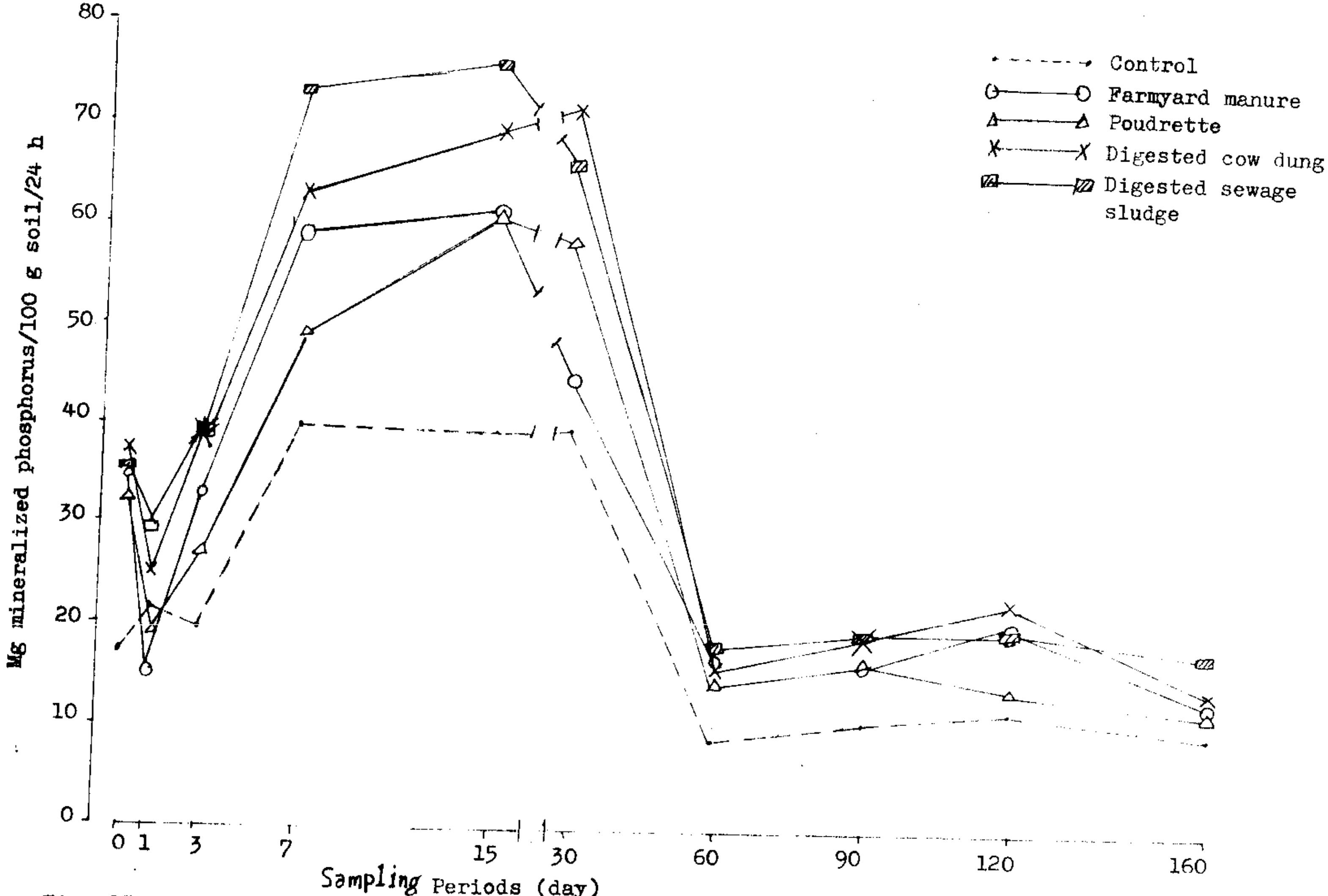

Fig. 15 - Phosphatase (Nuclease) activity in alluvial soil treated by different organic manures

to reach the lowest level allover the experimental period. The peak of promoted phosphatase activity and the inhibition followed it are directly related with total microbial counts in soil. The results obtained experimentally in this investigation (Tables 8-13) revealed a peak of high counts for a period included in the time 15-60 days followed by notable decrease thereafter. These results were in accordance with Chhonkar and Tarafdar (1984) and Hicksch et al. (1984) who stated that increasing the fungal population of the soil enhanced the phosphatase activity. The phosphatase activity showed clearly higher figures in treated soils than control. Here, another example of the positive relation between the phosphatase activity and the total microbial count is the similar respond of both phenomena to the kind of the tested organic manures. The highest recorded figures of phosphatase activity were in the pots of alluvial soil treated with biogas manures i.e. digested cow dung and sewage sludge, with the superiority of sewage sludge in this concern. In the same time the highest recorded figures for total bacterial, fungal and actinomycetes counts were recorded in the same treatments but with the superiority of digested cow dung in this case. The traditional organic manures showed less stimulative action than digested manures, the farmyard manure revealed more activity than poudrette specially in the period of 3-15 days and to be equal at the 15 days period. When the phosphatase activity was depressed in the period of 60-150 days, the recorded figures for the 4 kinds of organic manures were very close, although still slightly higher than control.

Earlier investigators referred that the phosphatase activity was highest in soil containing high organic matter than those with low content (Keilling, 1964, Rankov and Dinitrov, 1971 and El-Shimi, 1976), which is the same results appearing in this research.

It was expected that the phosphatase activity in sandy soil (Table 16 & Fig. 16) would be much less than alluvial soil. This is quite clear when comparing the average of the released inorganic phosphorus in both soils. The average ranged from 22 mg P/100 g dry soil in the control of the alluvial soil to 39.5 mg in the digested sewage sludge treatment, while it was 15 mg in the control and 26.5 in the digested cow dung treatment of the sandy soil. This can be also deduced to the lower counts of soil microorganisms. El-Shimi (1976) reported similar results when he found that the calcareous sandy loam soil poor in organic matter showed the lowest values of phosphatase activity while the highest were obtained with alluvial clay soils. Also, Verstraete

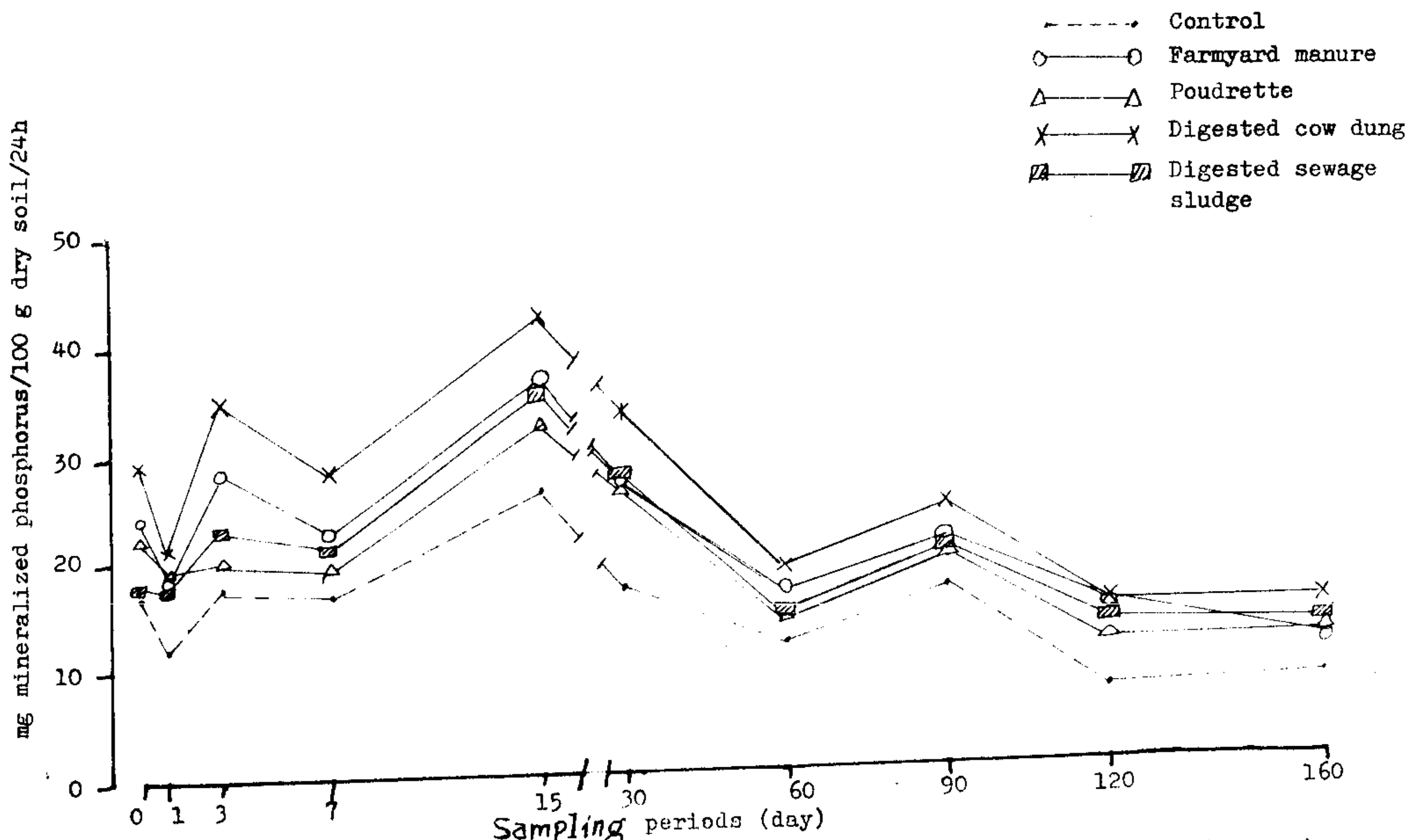

Fig. 16 - Phosphatase (Nuclease) activity in sandy soil treated by different organic manures

and Voets (1976) and Mathiur and Levesque (1980) found that phosphatase activity increased with increasing specific geometric surface of the structural units of rendizin soil. The application of organic manures to sandy soil stimulated the activity of phosphatase enzymes in a trend partially analogous to that appearing in the alluvial soil. The treated soil showed higher activity than control in the initial samples, which lasted to the end of the experimental period. A lag period of inhibited activity on the first day sample was observed before the catalytic reaction was favoured on the third day. However, the peak of enzymatic activity was delayed in the sandy soil to the 15th day showing slight depression on the 7th day. This slight depression may be a result of the inhibitory effect of the by-products of the decomposition of the organic manures. The inhibitory effect appeared only in the sandy soil since the alluvial soil have high adsorption potential exceeds that of sandy soil which masked the inhibitive effect of organic manure degradation by-products. Later in the experimental period the phosphatase activity was lessened to the lowest level from the 60th to the 160th day showing slight stimulation on the 90 days samples.

When comparing the effect of the tested organic manures on phosphatase in the sandy soil it was observed that there was no great differences in their activation efficiency or in their activation trend. However, the most stimulation was recorded in the digested cow dung treatment followed by farmyard manure then digested sewage sludge and poudrette. It is clear that the organic manures originating from the sanitary stations were less effective in enhancing the phosphatase activity than those originating from animal deposits. It seems that the former group contains relatively high concentration of heavy metals which may inhibit the catalytic reaction of phosphatase enzymes (Ras'kova et al., 1983).

4.3.3. Urease:

Table 17 illustrated by Fig. 17 shows the urease activity in alluvial soil. The initial samples revealed that the tested organic manures contain considerable counts of urea hydrolyzers since the urease activity at time 0 was clearly higher in treated soil than control.

The urea cleavage was enhanced directly after treatment without the need to a lag period. This was clear when the 1st day samples showed apparently accelerated figures of urea hydrolysis. It seems that the urease possessed by most of these microorganisms is likely to be of the constitutive type. Alexander (1977) mentioned that

Table 17 - Urease activity in alluvial and sandy soils treated by different organic manures.

(Percentage of hydrolyzed urea on dry basis

Periods (day)	Alluvial soil					Sandy soil				
	Control	Traditional organic manures		Digested organic manures		Control	Traditional organic manures		Digested organic manures	
		FYM	Poudrette	Cow dung	Sewage sludge		FYM	Poudrette	Cow dung	Sewage sludge
0	54	63	64	63	55	42	56	55	53	57
1	66	68	70	68	77	56	66	67	70	69
3	70	78	76	90	76	61	64	64	66	65
7	63	75	70	78	79	59	64	66	83	81
15	63	68	67	80	75	62	65	65	70	67
30	67	76	71	75	74	54	58	55	58	58
60	62	68	71	74	72	52	58	55	60	57
90	67	74	75	76	76	47	53	50	52	51
120	65	77	72	78	77	44	59	55	55	56
160	55	66	68	70	67	47	56	56	56	55
Average	63.2	71.3	70.4	75.2	72.8	52.4	59.5	58.8	62.3	61.6

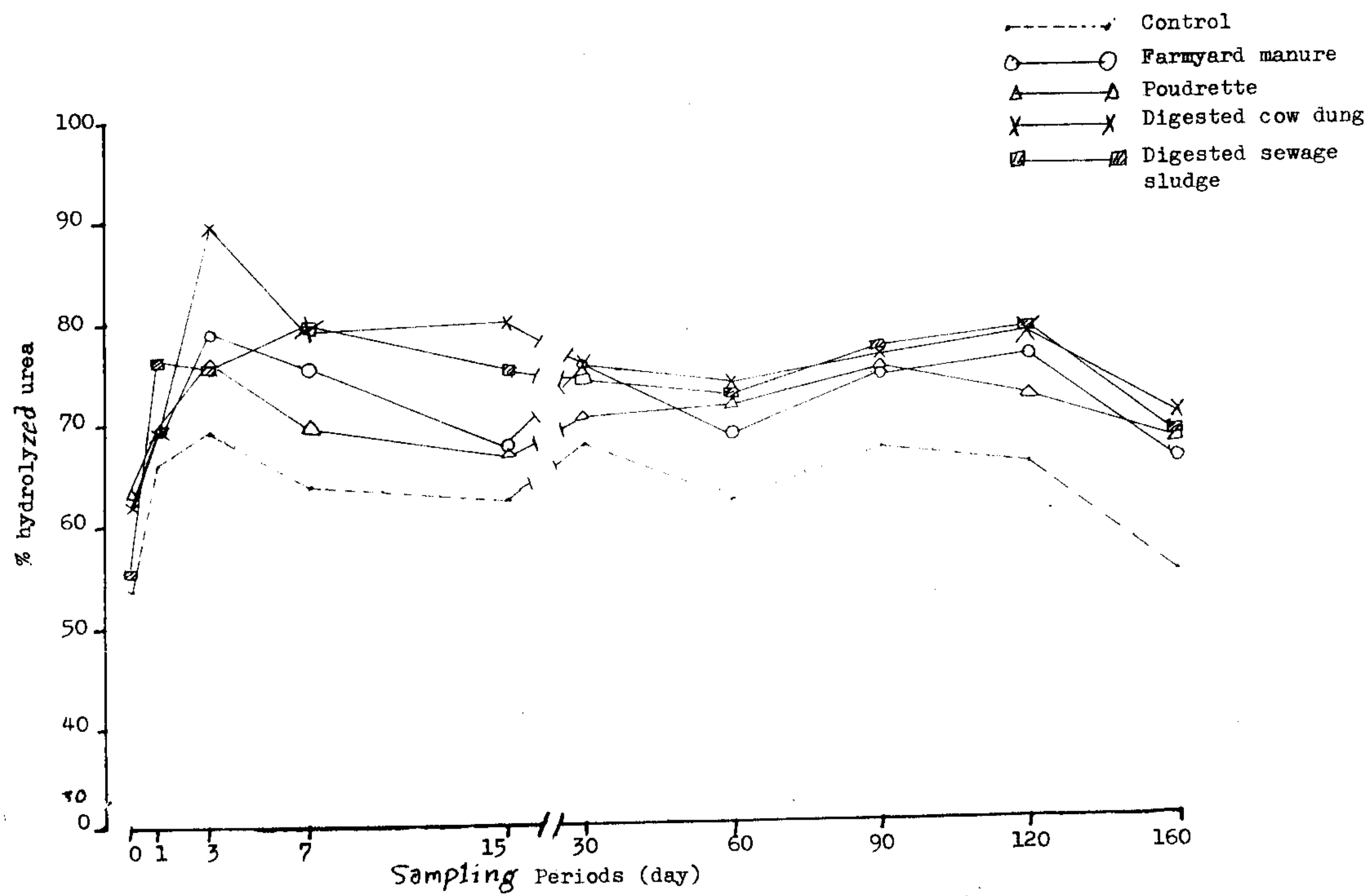

Fig. 17 - Urease activity in alluvial soil treated by different organic manures

urease in some species of soil microorganisms is constitutive while in others, it is inducible enzyme. The urease activity continued to be stimulated to show a peak on the third day sample followed by sharp decrease on the seventh day in all treatments except the alluvial soil treated with digested sewage sludge. In this particular treatment the urease stimulation extended for 7 days showing gradual decrease thereafter. The rapid decrease in the urease activity can be attributed to the rapid hydrolysis of urea which result in the exhaustion of the substrate in few days. However, the level of the catalytic reaction remained higher than the initial sample, a phenomenon was not observed in the other studied enzymes. The position of urea as an intermediate in microbial metabolism, i.e. a result of the activity of phosphatase in hydrolyzing nucleic acids help in its continuous production in soil, which contribute in great part in favouring the urease activity for longer periods. On the other hand, the enzyme, to the extent that it exists apart from cells, probably is adsorbed on clay and organic colloids, to which it has a strong affinity. Complexing with soil constituents increase appreciably the resistance of urease to protein degrading enzymes that otherwise would readily destroy the catalyst (Burns et al., 1972).

The most efficient organic manure in enhancing the proliferation of urea hydrolyzing microorganisms, and urease activity as a result was the digested cow dung. This may be deduced to the expected high quantity of urea in this manure, which is hardly to by hydrolyzed in the anaerobic conditions of digestion. Following cow dung in this respect was the digested sewage sludge. It is well known that sewage sludge contains considerable concentrations of several heavy metals which may act in the inhibition of urease activity.
Tabatabai (1977) found that about 20 trace elements found in sludge inhibit urease activity in soils. So the urea hydrolyzation appeared less promoted in this treatment than digested cow dung. The least stimulation for urease activity was observed in the pots treated with the traditional organic manure, i.e. farmyard manure and poudrette, respectively. It is well known that the normal method of storing farmyard manure in Egypt results in the leaching of high percentage of the urine from it, besides the expected hydrolysis of urea in the storing time may result in its pouverty in the substrate of urease reaction. The promotion of urease activity as a result of organic matter application to soil was reported by several earlier investigators. Among them were Galastyan (1958), Skujins and Mc-Laren (1969), El-Essawi et al. (1973), Borie and Fuentealba

(1982) and Kumar and Wagenet (1984), However Galstyan and Astvatsatryan (1958) stated that urease activity did not depend on humus content of the soil.

Sandy soil showed lower level of urease activity than alluvial soil in both control and soil treated by any of the tested organic manures (Table 17 and Fig. 18). This result is coordinating with that of El-Essawi et al. (1973) and El-Shimi (1976). Here, also no lag period for the enzyme stimulation was needed, as the urea hydrolyses showed high figures on the first day. But the peaks of enzymatic activity were delayed to the seventh day instead of 3 days in the case of alluvial soil showing slight decrease on the 3rd day samples in all sandy soil treatments except control. This delay may be attributed to the possible relation between the activity of urease and phosphatase since the former acts on one of the latters by-products.

The urease activity was gradually decreased thereafter to reach almost the initial level 30 days from the commencement . At this period and to the end of the experiment the catalytic reaction was very close in all the organic manures and, with the exception of some slight fluctuations,

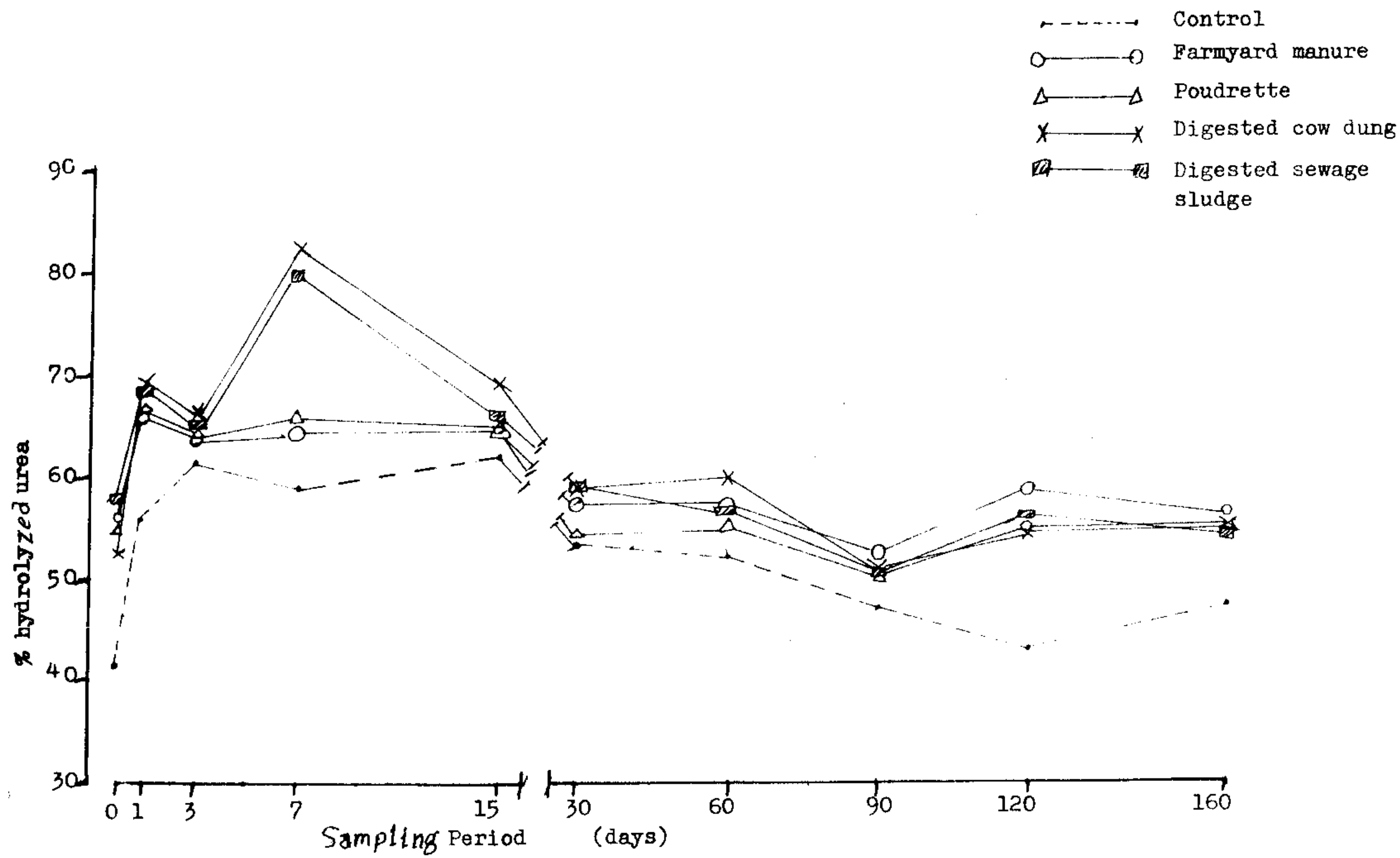

Fig. 18 - Urease activity in sandy soil treated by different organic manures

can be considered constant. It is worthy to note that the urease activity showed apparently higher figures in all treatments than control all over the experimental period. The different organic manures revealed analogous trend to that observed in the alluvial soil. The stimulation efficiency can be ordered as follows: digested cow dung > digested sewage sludge > farmyard manure > poudrette.

4.3.4. Nitrogenase:

Although the application of organic manures to alluvial soil increased its nitrogen fixation potential on the 0 time, it showed sharp depression on the 1st day samples (Table 18 and Fig. 19). It is clear that a lag period was needed for the microorganisms to be adapted for the new environment. The nitrogenase activity was gradually enhanced thereafter to show a peak 15 days after application in all treatments except digested sewage sludge where the highest activity was recorded in the period 7-15 days. The recorded stimulation of nitrogenase in treated soil is likely to be a result of the enrichment of the soil with energy sources necessary for the proliferation of nitrogen fixers rather than the increase of the specific populations. When these energy sources began to be exhausted the nitrogenase activity was clearly inhibited from

Table 18 - Nitrogenase activity in alluvial and sandy soil treated by different organic manures.

µ gm N_2 fixed/g dry soil/hour

Periods (day)	Alluvial soil					Sandy soil				
	Control	Traditional organic manures		Digested organic manures		Control	Traditional organic manures		Digested organic manures	
		FYM	Poudrette	Cow dung	Sewage sludge		FYM	Poudrette	Cow dung	Sewage sludge
0	9.7	13.0	10.9	13.3	11.5	1.3	2.4	1.8	2.9	1.9
1	5.8	6.8	5.4	7.7	8.4	0.8	1.5	1.3	2.1	1.9
3	6.7	8.3	6.9	10.7	8.2	2.0	2.6	2.7	3.7	3.0
7	10.9	10.3	10.6	12.3	13.5	2.1	3.1	3.5	5.2	4.9
15	11.2	15.5	12.6	17.3	13.5	2.8	4.0	4.0	5.1	4.0
30	7.6	10.7	8.5	11.8	8.9	1.7	2.6	2.2	2.6	1.7
60	4.5	4.8	4.5	7.5	3.8	0.9	1.4	0.7	1.1	0.7
90	4.5	5.9	4.9	4.3	4.4	1.0	1.4	0.9	1.6	1.7
120	3.7	3.8	2.5	4.2	4.0	0.7	0.6	0.6	0.7	0.6
160	2.9	3.5	2.5	4.0	4.0	0.6	0.8	0.7	0.8	0.6
Average	6.7	8.3	6.9	9.3	8.0	1.4	2.0	1.8	2.6	2.1

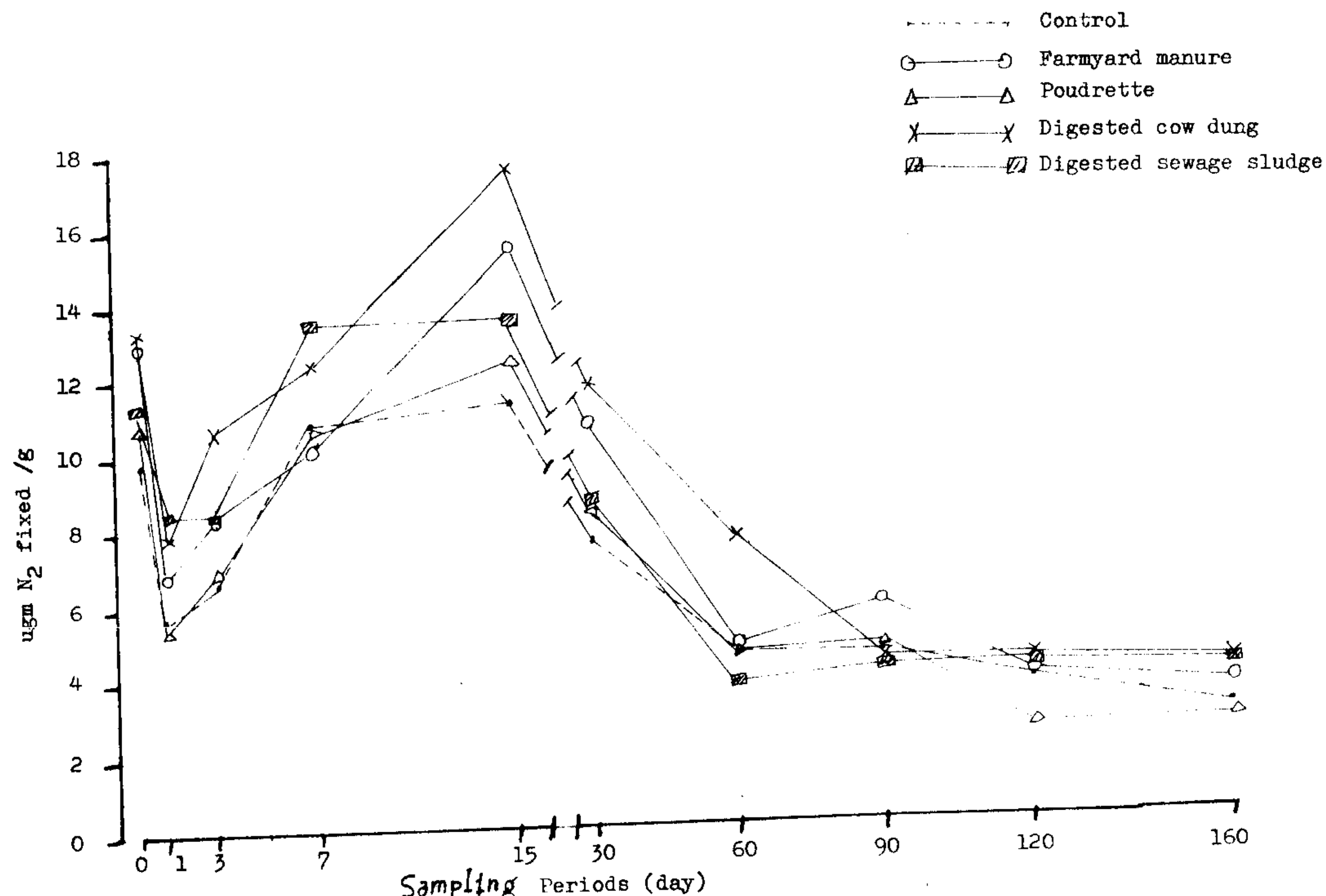

Fig. 19 - Actual nitrogenase activity in Alluvial soil treated by different organic manures

the 15th to the 60th day where it reached the lowest level all over the experiment. The enzyme showed relative stability at this low level to the end of the experimental period in all treatments except poudrette where it showed accelerated inhibition than the 60 day level. Several investigators revealed results agreeable with those obtained in this research. Ishac et al. (1970), Monib et al. (1970)& Neweigy et al.(1984) found that the application of organic matter increased the counts of non-symbiotic nitrogen fixing bacteria and increased the efficiency of nitrogen fixation of the soil correspondingly. Except for few scattared samples, the treated alluvial soil generally showed higher nitrogenase activity than control. The least percentage of the control nitrogenase activity was recorded on the 120th day sample in poudrette treatment to be 68% while the highest percentage was 167% on the 60th day sample of the digested cow dung treatment. This latter treatment showed the highest figures for nitrogen fixation allover the experiment followed by FYM except for the 7th day samples for both treatments. This can be deduced to the expected degradation of complex carbohydrate compounds to more available energy sources during the anaerobic digestion of cow dung and the storage period of farmyard manure. Alexander (1977) stated that the availability of simple energy sources is a major factor limiting the rate and extent of N_2 assimilation by heterotrophic populations. Following the digested cow dung and farmyard manure in activating nitrogenase enzyme, there was the digested sewage sludge, while poudrette showed the least activity. Here also, the decomposition of complex carbohydrates to simple energy sources during the anaerobic digestion of sewage sludge may contribute for the superiority of digested sewage sludge than poudrette.

The nitrogenase activity in sandy soil was apparently lower than alluvial soil. The fixed nitrogen in one hour per one gram of sandy soil was 1.3, 2.4, 1.8, 2.9 and 1.9 microgram for control, farmyard manure, poudrette, digested cow dung and sewage sludge, respectively in the initial samples, while the corresponding treatments in the alluvial soil fixed 9.7, 13.0, 10.1, 13.3 and 11.5 micrograms N_2/1 gram/1 hour (Table 17 and Figure 20). This could be deduced to the low moisture content and high O_2 tension of the sandy soil. Rice et al. (1967) and Magdoff and Bouldin (1970) stated that most soils having adequate moisture, the rate of nitrogen fixation is higher when the soil is anaerobic than when O_2 is present. On the otherhand, the nitrogenase activity was reported by Rother and Millbank (1983) to be lower in loose soil than in cores. They attributed these effects to excessive compaction and thus reduced aeration of the small diameter cores.

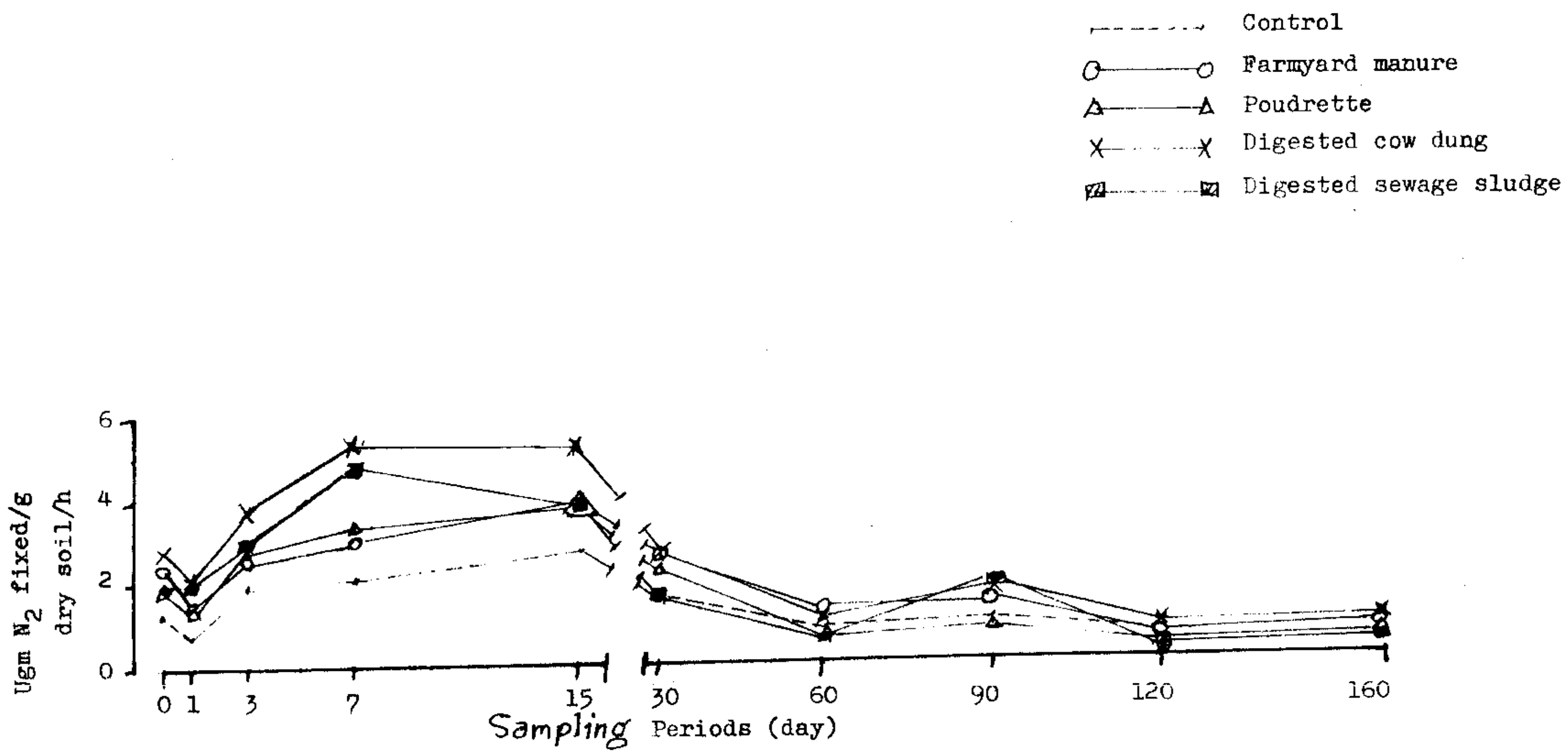

Fig. 20 - Actual nitrogenase activity in sandy soil treated by different organic manures

The phenomenon of lessened nitrogenase activity in sandy soil was observed all over the experimental period and in all treatments. The highest figure was recorded in the 7th day sample of digested cow dung treatment to be 5.2 ugm N_2/1 gram/1 hour, while it reached 17.3 U gm in the 15th day sample of the same treatment in alluvial soil. The nitrogenase activity of sandy soil was promoted by the application of organic manures. This promotion was observed on the 0 time samples and continued to be apparently clear till the 30th day samples. The nitrogen fixation capacity of the soil increased by 185, 139, 224, 147% of the control in the initial samples of farmyard manure, poudrette, digested cow dung and sewage sludge, respectively. In accordance with this result is the findings of Monib et al. (1970) and Neweigy et al. (1984) who stated that application of organic matter to sandy soil increased the counts of non symbiotic nitrogen fixing bacteria and increased the efficiency of nitrogen fixation correspondingly.

The nitrogenase activity was inhibited in all treatments for one day lag period, then exhibited greater activity with time showing the maximum N_2-fixation in the period 7-15 days after application. The biogas manures reached maximum nitrogenase activation on the 7th day,

while the traditional manures and control soil showed the peak on the 15th day. Thereafter the catalytic reaction was sharply depressed to reach a level lower than that of the initial samples on the 60th day and to the end of the experimental period.
This trend is analogous to that of the alluvial soil which ensure the positive relation between the available energy sources and the nitrogenase activity. The digested cow dung manure favoured the enzymatic activity more than the other tested manures. Following to the cow dung in quantity and analogous in trend was the digested sewage sludge. The least stimulation was observed in the farmyard manure and poudrette treatments.

The greater activity exhibited by the biogas digested manures together with their rapid stimulation of nitrogenase favour the proposal that the decomposition of complex organic nutrients to simple products during the anaerobic digestion for biogas production, enhances the proliferation of nitrogen fixers when the simple products diffuse to their microhabitat.

4.4. Chemical properties of soil:

It was found worthy to study the changes in the carbon and nitrogen content of soil as affected by the different microbial activities which had been enhanced by the application of organic manures.

4.4.1. Organic carbon:

Table 19 and Fig. 21 show that the organic carbon content in the control of alluvial soil was 1.37% in the 0 time sample which tend to be gradually degraded till the end of the experimental period when it was 1.2%. It is well known that the Egyptian soil is generally poor in its content of organic matter, that it rarely exceeds 2% (Badran, 1983). The application of 800 kg organic matter per feddan as organic manures resulted in limited increase in the carbon content of the soil. The highest figures were recorded in the initial sample of the digested cow dung treatment to be 1.424%, which is almost the same figure for the rest of the treatments. This was expected since the applicated amount of the different manures was counted on the base of equal organic matter content. Increasing the organic carbon content of the soil as a result of organic manuring was reported by several investigators (Kudack, 1978; Pomares and Pratt, 1979; Ramaswami et al., 1979; Singh et al., 1980 and Pokorna, 1984). The organic manures used in this investigation were specially studied by other investigators. Lunt (1953) and Alaa-El-Din et al. (1984b) stated that digested sewage sludge and other biogas manures increased organic matter content and helped

Table 19 - Changes in organic carbon content in alluvial and sandy soils treated by different organic manures (figures in ppm on oven dry basis).

Periods (days)	Alluvial Soil					Sandy Soil				
	Control	Traditional organic manures		Digested organic manures (Biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)
0	13770	14233	14238	14242	14233	2048	2494	2476	2512	2494
15	13286	13627	13692	13597	13653	1858	2131	2129	2145	2153
30	12766	13051	13144	12993	13094	1630	2006	2031	1984	2047
60	12348	12588	12631	12564	12627	1496	1818	1842	1748	1884
90	12206	12406	12477	12404	12456	1386	1681	1665	1581	1703
120	12093	12262	12318	12276	12291	1380	1613	1620	1554	1660
160	11991	12160	12209	12184	12188	1384	1562	1564	1547	1605

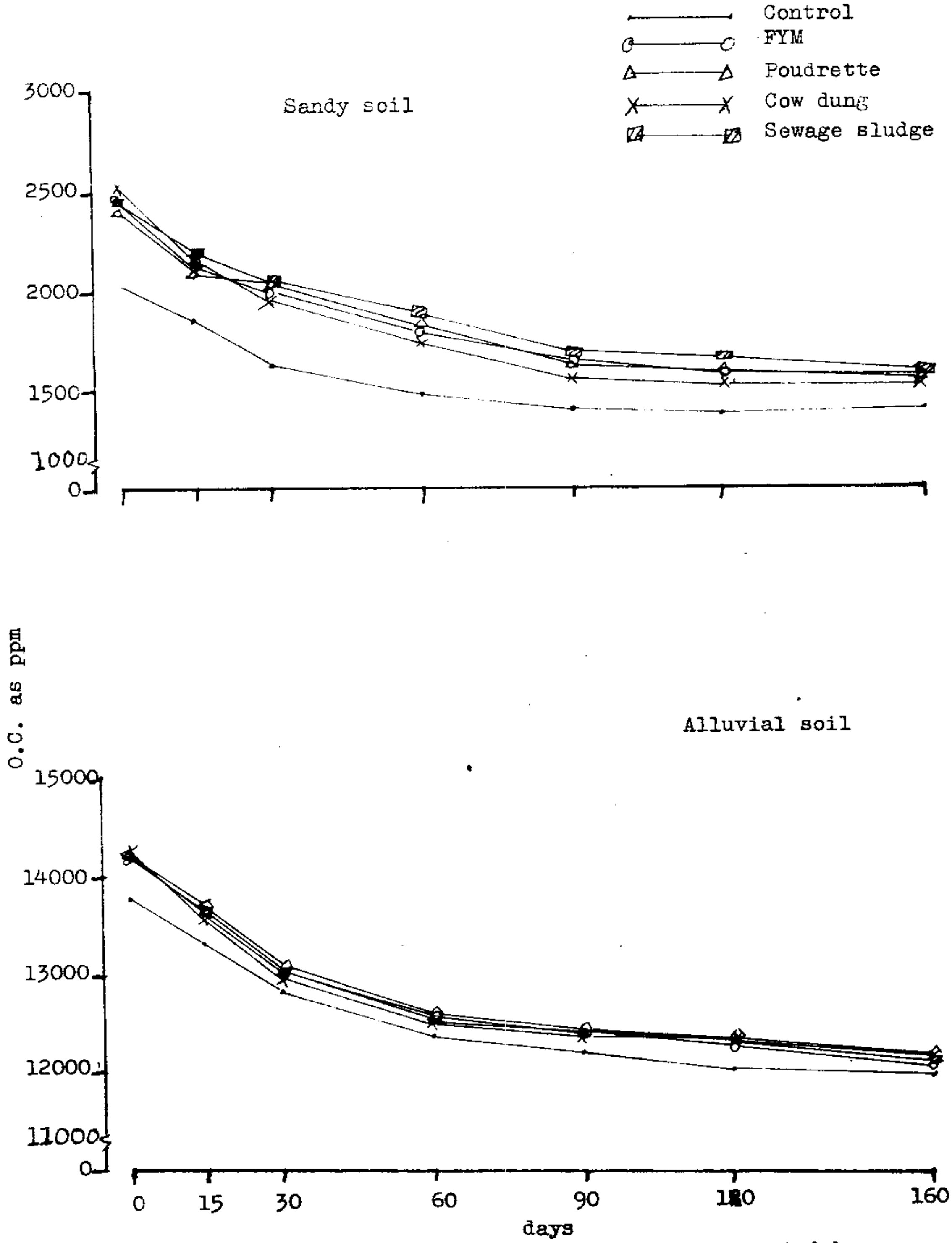

Fig. 21 - Changes of the organic carbon in soils treated by different organic manures.

maintaining higher levels of organic carbon in the soil. Abdou et al. (1969) and Hamdi et al. (1969) added farmyard manure, while Diez and Weigelt (1980) used sewage sludge (Poudrette), and all stated increased amounts of organic carbon in the soil as a result.

A gradual decomposition of the organic matter was exhibited till the end of the experiment, but with greater rate in the first 30 days of the process. So, the relation between the promoted microbial activity early in the experimental period and the rapid organic matter decomposition in the same period can be easily demonstrated.

Although the figures of organic carbon in the different organic manures are very close, it can be recognized that the least carbon content was in the digested cow dung treatment for 3 months period after application. This was quite expected since the highest microbial stimulation was experimentally recorded in this investigation when the soil received this particular organic manure. Hamdi et al. (1969); El-Shahawy (1972), Hashem (1980) and many other workers observed gradual decrease in the organic matter content of the soil following its manuring with different organic residues. They suggested microbiological decomposition of the added organic compounds which is the same results obtained in the herein research.

The organic carbon content of the control of sandy soil was low as 2048 ppm in the initial sample (Table 19, Fig. 21). Manuring the sandy soil increased its carbon content to be about 2500 ppm in all treatments. The organic carbon content of the sandy soil followed the same trend observed in the alluvial soil concerning gradual decomposition of organic matter with greater rate on the first 30 days and that the least carbon content was in the digested cow dung treatment, although the figures of all treatments were very close.

4.4.2. Total nitrogen:

Manuring the alluvial soil added to the total nitrogen content of the control 45, 37, 70 and 43 ppm in the farmyard manure, poudrette, digested cow dung and sewage sludge treatments, respectively (Table 20, Fig. 22). The total nitrogen content of the alluvial soil decreased early in the experimental period till the 30th day sample then gradually increased thereafter till the end of the experimental period. This trend was the same in both control and manured soil. It is clear that there was negative relation between the total nitrogen content and the

Table 20 - Changes in total nitrogen content in alluvial and sandy soils treated by different organic manures (figures in ppm on oven dry basis).

Periods (days)	Alluvial Soil					Sandy Soil				
	Control	Traditional organic manures		Digested organic manures (Biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)
0	1608	1653	1645	1678	1651	252	293	290	315	293
15	1592	1640	1636	1661	1641	247	287	284	298	286
30	1596	1638	1634	1654	1637	254	296	290	311	296
60	1613	1656	1650	1686	1651	260	308	299	329	310
90	1621	1678	1667	1711	1669	260	310	300	336	310
120	1617	1674	1660	1702	1666	262	313	302	347	317
160	1627	1689	1673	1728	1681	266	320	307	354	319

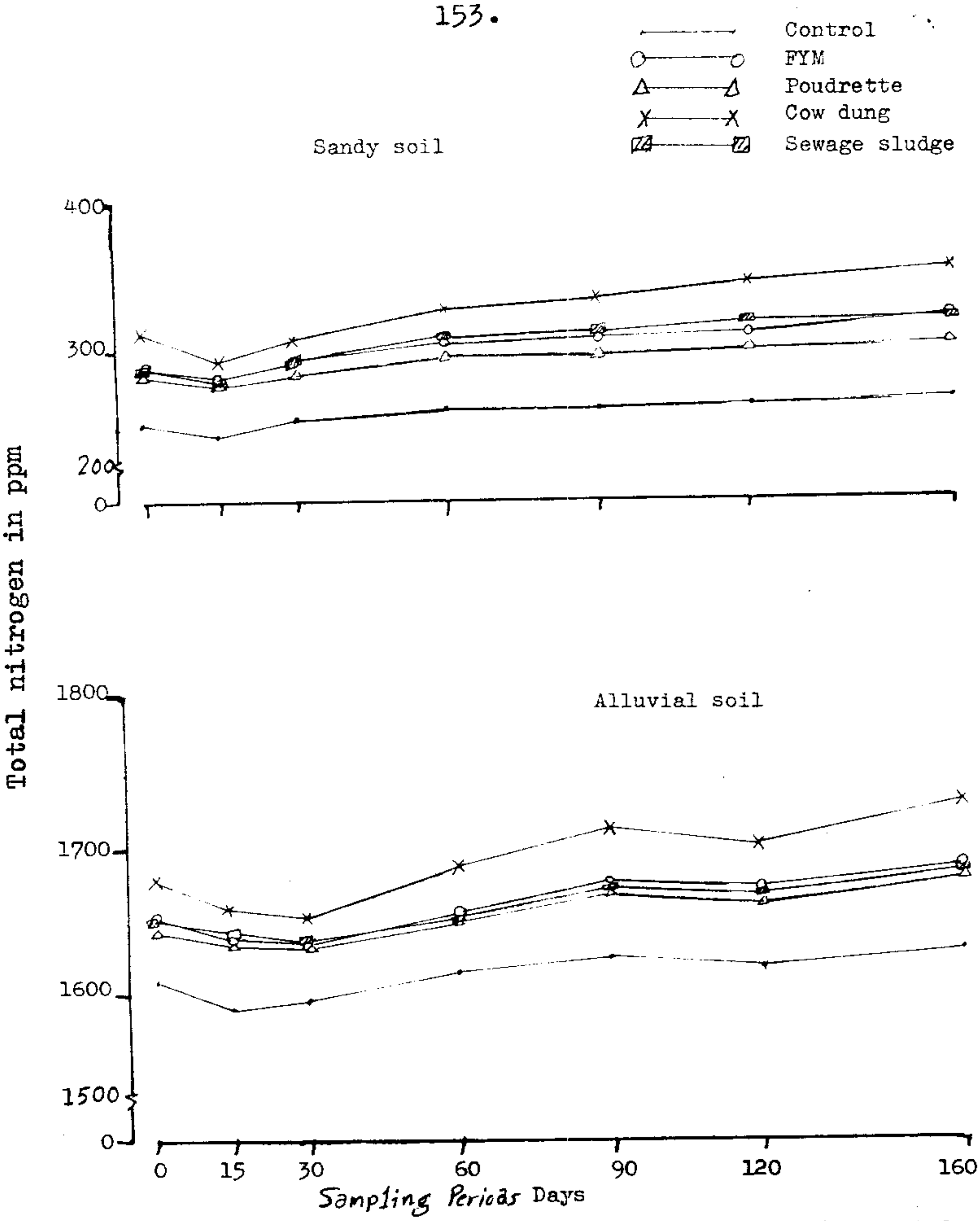

Fig. 22 - Changes of the total nitrogen in the soils treated by different organic manures.

total counts of the soil microorganisms. It is worthy to note that the digested cow dung treatment showed the highest level of total nitrogen content all over the experimental period, while the other three manures exhibited very close level which were much less than the former.

The same trend was observed in sandy soil (Table 20, Fig. 22) but to a less extent, since the early decrease of total nitrogen content and the following increase were apparently lower than alluvial soil. Lunt (1953) found that application of digested sludge to loamy soils resulted in large increase in total nitrogen. Later, Khalil (1979), Hashem (1980) and Harding et al. (1985) reached the same conclusion which is in accordance with the results appearing in this investigation.

4.4.3. C:N ratio:

The C:N ratio in the control of both sandy and alluvial soil was too narrow. The addition of any of the tested organic manures didn't changed much in the control ratio at 0 time (Table 21). This can be expected since the C:N ratio of the added manures were also narrow ranging from 12.3:1 (digested sewage sludge) to 17.9:1 (digested cow dung) (Table 1). A manure having this low

Table 21 - Changes in carbon:nitrogen ratio in alluvial and sandy soils treated by different organic manures.

Periods (days)	Alluvial Soil					Sandy Soil				
	Control	Traditional organic manures		Digested organic manures (Biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)
0	8.6	8.6	8.7	8.5	8.6	8.2	8.6	8.6	8.0	8.6
15	8.4	8.3	8.4	8.2	8.3	7.6	7.5	7.5	7.2	7.6
30	8.0	8.0	8.0	7.9	8.0	6.5	6.8	7.0	6.4	7.0
60	7.7	7.6	7.7	7.5	7.6	5.8	6.0	6.2	5.4	6.0
90	7.5	7.4	7.5	7.3	7.5	5.4	5.5	5.6	4.7	5.5
120	7.5	7.4	7.4	7.2	7.4	5.3	5.2	5.4	4.5	5.3
160	7.4	7.2	7.3	7.1	7.3	5.1	4.9	5.1	4.4	5.1

C:N ratio can hardly affect the soil C:N ratio. Gradual narrowing was observed in all treatments and control which went along with the proliferation of the soil microorganisms indicating the loss of organic carbon in amounts higher than nitrogen. This is quite expected since a considerable amount of carbon is lost as Co_2 while the loss of nitrogen is limited. Antoun (1972) and El-Shahawy (1972) suggested the same conclusion when they observed that the C:N ratio of the manured soil tended, with time, to become narrower and reached its least value at the end of the experimental period.

4.4.4. Soluble nitrogen:

4.4.4.1. NH_4-N:

The tested organic manures were found to contain different amounts of NH_4-N (ammoniacal nitrogen) (Table 1). So, when added to sandy or alluvial soil, the initial samples showed corresponding amounts to the contents of the added fertilizer (Table 22 and Fig. 23). The ammoniacal nitrogen was rapidly assimilated by soil microorganisms showing sharp decrease 15 days after manuring. Thereafter the determined amounts of NH_4-N gradually decreased till the 90th day sample followed by slight build up till the end of the experimental period. It seems that the mineralization of the organic nitrogen of the dead

Table 22 - Changes in ammoniacal nitrogen content in alluvial and sandy soils treated by different organic manures (figures in ppm on dry basis)

Periods (days)	Alluvial Soil					Sandy Soil				
	Control	Traditional organic manures		Digested organic manures (Biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)
0	12.061	27.319	24.050	34.369	37.783	4.308	9.651	11.753	19.659	18.627
15	6.056	6.129	5.985	9.807	7.716	3.727	4.349	3.651	4.659	4.597
30	6.537	8.210	8.282	9.299	9.299	3.211	3.529	2.929	3.529	3.882
60	5.661	6.489	6.075	6.449	7.356	2.884	3.097	2.741	3.382	3.418
90	4.110	3.704	3.867	3.948	4.070	2.718	3.741	2.152	3.281	3.671
120	4.285	5.085	5.448	5.666	6.683	3.479	5.716	4.784	5.095	4.473
160	4.503	4.576	5.012	5.448	5.987	2.795	3.479	2.795	3.105	3.416

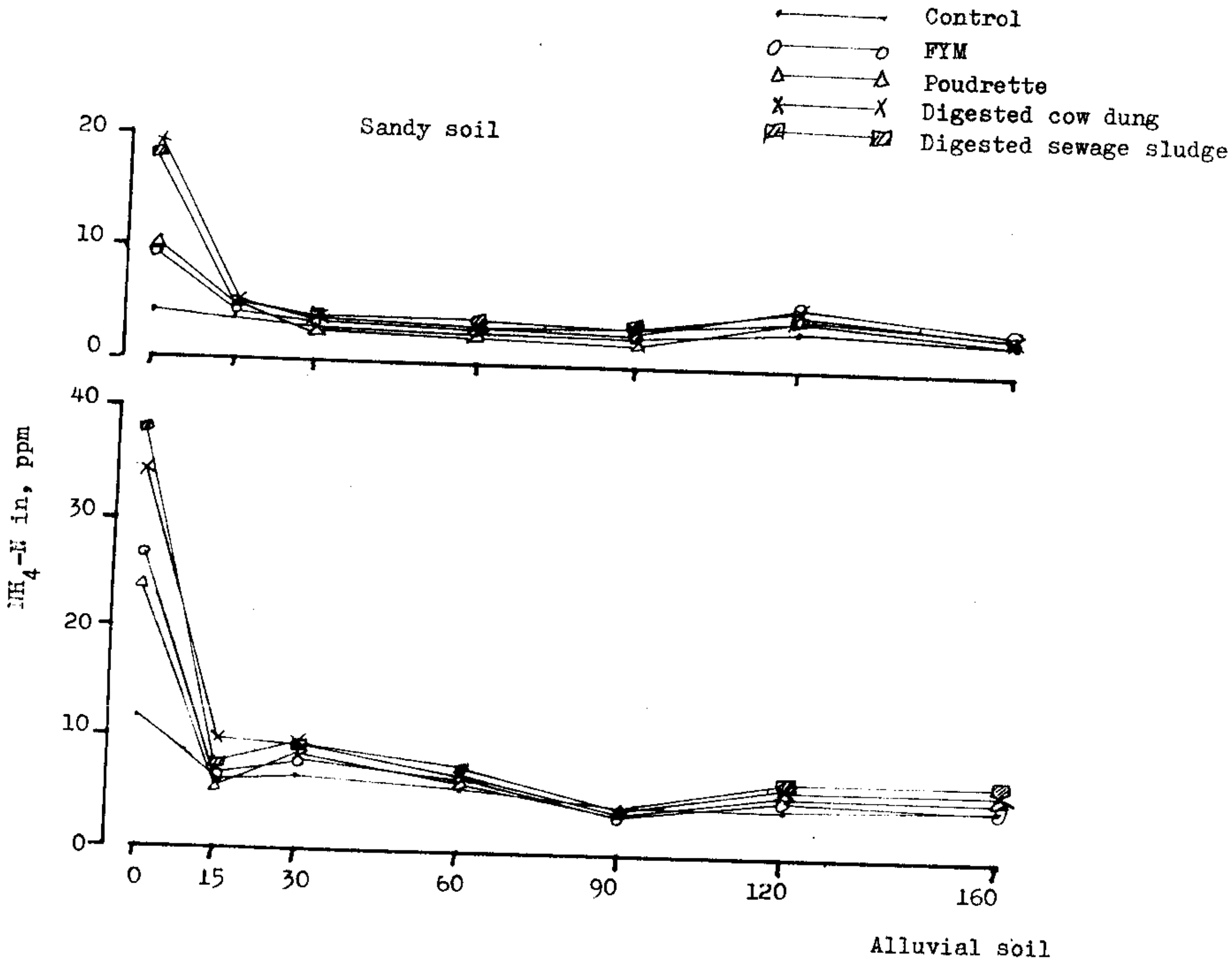

Fig. 23 - NH_4-N in soils treated by different organic manures

microbial protein overcame the assimilation of NH_4-N at the end of the experiment. The application of organic manures was reported to increase nitrogen mineralization, (Ibrahim, 1964; Loginow, 1968; Tanikawa, 1968; Omar et al. 1970 and Khalil, 1979). There results are in accordance with the herein research, but later in the experimental period.

The same trend was observed in the sandy soil. In both sandy and alluvial soils, it was observed that the 4 tested organic manures showed the same level of NH_4-N almost allover the experimental period except for the initial sample. In this particular sample the NH_4-N amounts were in the order: digested sewage sludge > digested cow dung > farmyard manure > poudrette > control in alluvial soil, while the order was digested cow dung > digested sewage sludge > poudrette > farmyard manure > control in the case of sandy soil.

No_3-N :

The nitrate nitrogen content of the alluvial soil showed reverse trend to that of the NH_4-N (Table 23, Fig.24). The No_3^- ions tend to increase early in the experimental period till 60 days after manuring. The degree of nitrification was apparently higher in treated soil than control.

Table 23 - Changes in nitrate nitrogen content in alluvial and sandy soil treated by different organic manures (figures in ppm on dry basis)

Periods (days)	Alluvial Soil					Sandy Soil				
	Control	Traditional organic manures		Digested organic manures (Biogas manures)		Control	Traditional organic manures		Digested organic manures (biogas manures)	
	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)	Soil without organic manures	Farm-yard manure	Poud-rette	Cow dung (DCD)	Sewage sludge (DSS)
0	14.821	19.474	22.234	14.677	16.784	2.314	3.454	3.097	2.670	2.563
15	18.318	25.168	28.270	18.606	24.868	4.100	7.270	7.518	6.772	5.716
30	20.054	28.192	34.223	35.822	40.181	6.318	9.743	11.190	17.087	15.886
60	22.858	33.730	34.224	37.283	40.136	6.873	12.393	14.103	21.191	18.662
90	23.857	35.380	34.891	36.153	33.669	7.165	10.414	8.401	10.661	9.214
120	30.000	48.974	48.101	56.676	61.109	7.021	11.996	10.066	10.501	6.959
160	26.521	46.794	42.435	54.568	56.821	5.903	10.052	7.891	8.015	7.207

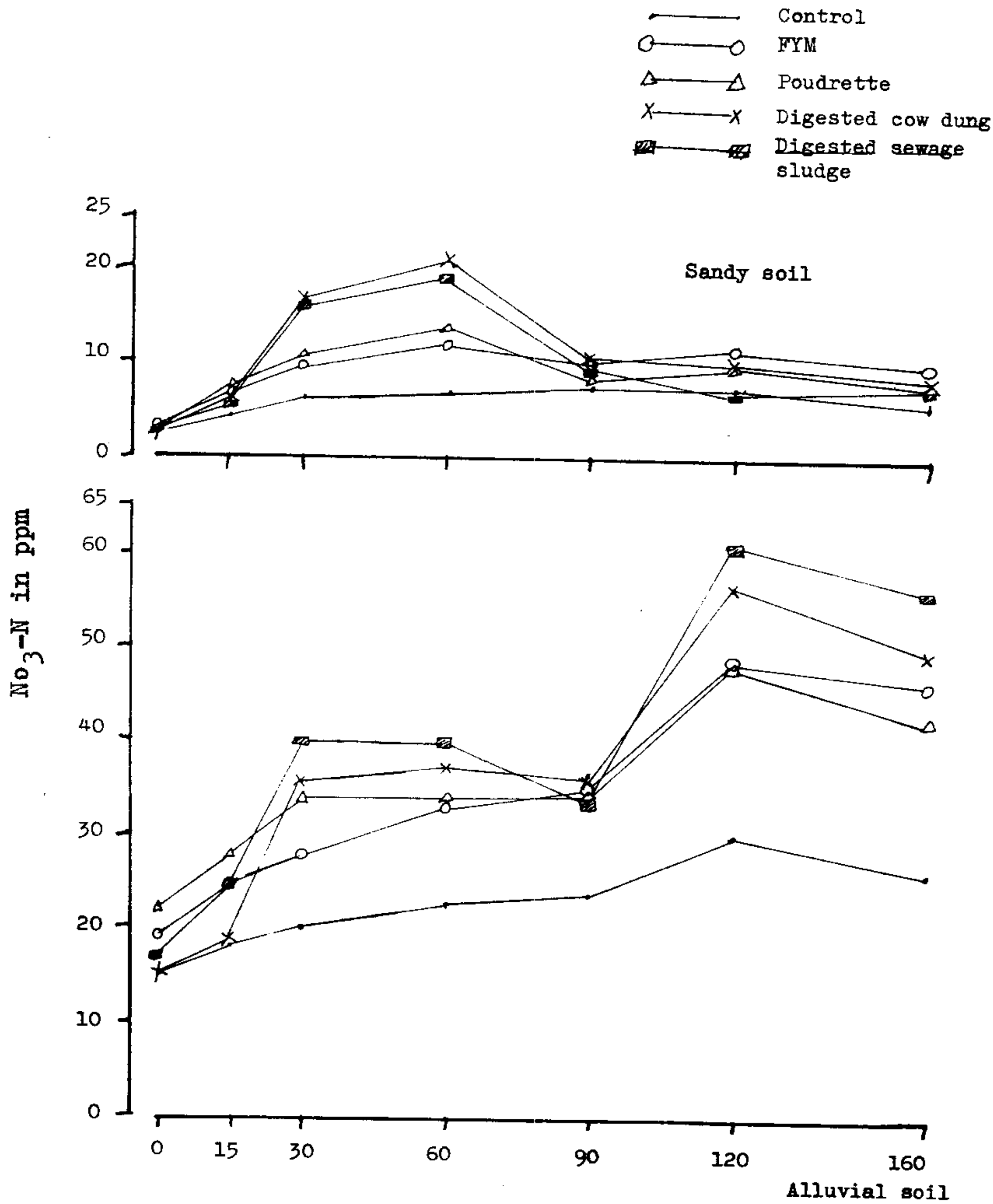

Fig. 24 - No_3-N in soils treated by different organic manures.

The maximum stimulation of nitrifiers was observed in the digested sewage sludge treatment in the period of 30-60 days followed by digested cow dung then poudrette and farmyard manure, respectively. However, the extracted amounts of No_3-N showed slight decrease on the 90th day sample. Another peak of nitrate nitrogen content was recorded thereafter showing the highest concentration on the 120th day sample. During this second period of high No_3-N content, the organic manures exhibited almost the same order of nitrifiers stimulation , since the biogas manures exceeded the traditional manures. The accumulation of nitrate nitrogen in the pots of the herein investigation is quite possible since no vegetation to assimilate the produced amounts of nitrates. The accumulating review denoted to the apparent stimulation of the nitrification process happening when the soil receive organic manures. Loginow (1968), Minki and Mori (1968), Omar et al. (1970), Khalil (1979) and others reported increasing amounts of nitrate ion added to the manured soil, which is coordinating with our results.

The initial samples of sandy soil showed equal amounts of nitrate nitrogen in control and manured soil (Table 23, Fig. 24). It may be proposed that the irrigation of the soil after manuring leached the readily soluble and weakly adhered anion from the sandy soil. When the soil microorganisms proliferated, the following samples showed the same trend as alluvial soil i.e. stimulating the nitrification process till it showed a peak of high amounts of No_3^-N on the 60th day sample. A sharp decrease of No_3^- -N was recorded thereafter 90 days after manuring where it still constant to the end of the experiment period. Hamdi et al. (1969), during their study to the nitrogen mineralization of organic manures added to sandy soil, suggested that the gradual decrease in ammoniacal nitrogen was due to the conversion of NH_4^+ to No_3^- through the nitrification process. The low nitrate content at the beginning of the experiment began to increase gradually on the expense of ammonia. This is exactly the same results obtained in this investigation. However, Ibrahim (1964) reported that nitrification of NH_3-N was more rapid in sandy than loamy soil receiving farmyard manure.