II LITERATURE REVIEW ON TAPIOCA STARCH WASTES

2.1 Tapioca Starch Wastes

2.1.1 Manufacturing process   The text presented herein was taken after McGARRY et. al., (1972). Tapioca starch is produced in two types of processes. The first grade product is produced using centrifugation filtration and spray drying as the basic unit processes; its process is capital and low labour intensive and uses more water; the product is directed at overseas markets. In contrast, very little mechanization is utilized by the second grade starch producers which are often small private enterprise operations, low capital intensive and using very simple methods of separation by cloth filtration, gravity settling, decanting and drying on heated concrete slabs.

A flow diagram of the first grade starch plant is illustrated in Figure 1 Roots are transported by truck to the plant which must process them within 24 hrs to avoid degradation of the starch. The sand is then removed by dry rasping in a revolving drum and the peels by mechanical tumbling in a wash basin from which the root wash water is derived. The roots are then mechanically crushed releasing the starch granules from their surrounding cellulose matrix. Most of the cellulose material is removed by centrifugal means in the jet extractor and then by continuous centrifugation. The cellulose material or pulp is sold as duck feed provided that it is fresh or dewatered, dried and sold as filter feed if not. After primary centrifugation, the starch milk is seived through a series of three seives decreasing in pore size to assist in separating the starch from the small amount of pulp remaining. The pulp thereby recovered is recycled to the jet extractor and the processed starch milk fed to a second continuous centrifuge from which wastewater is derived and by which a more concentrated starch is produced. After dewatering to a paste-like substance in a basket centrifuge, the product is spray dried and packaged.

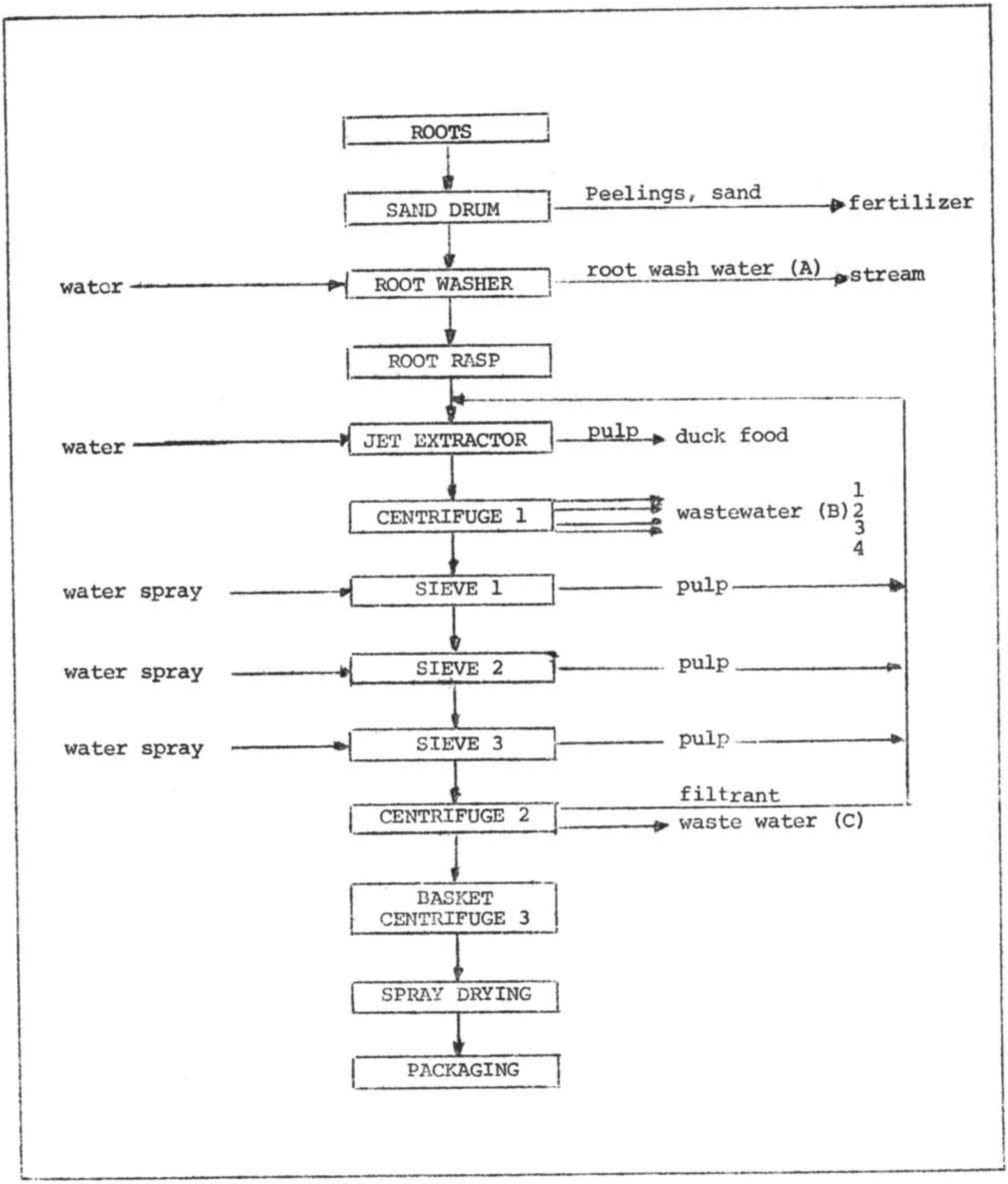

Figure 1 First Grade Tapioca Starch Process Flow Diagram

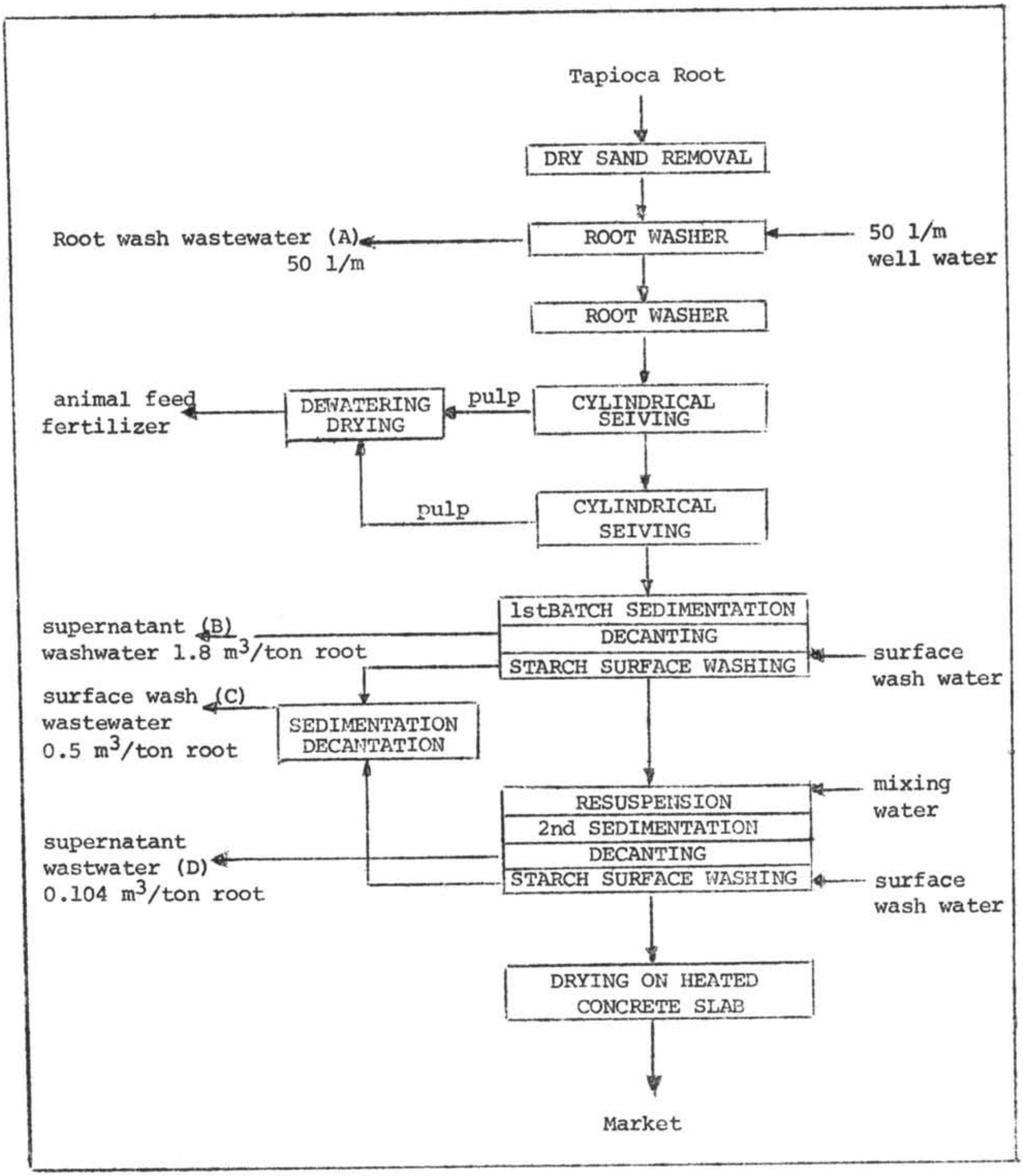

Figure 2 2nd Grade Tapioca Starch Production

In second grade tapioca refineries, (Figure 2) the initial stages of processing also include dry removal of sand, root washing and rasping. Starch separation from the cellulosic pulp is made in only one step by screening it through fine nylon mesh supported by a large cylindrical drum. The starch is sprayed through and the pulp slowly drawn off and collected for dewatering the starch milk is then seived again and released into large 1.2 m deep settling basins. After 24 hrs settling, the supernatant is removed by decantation and discharged to a river. The surface of the starch caked on the bottom is washed, the wash water from which is discharge to an outdoor lagoon. The starch is then resuspended and pumped to the second sedinentation basin again 1.2 m deed and 24 hrs detention time. The supernatant is then decanted and discharged to a nearly stream and the surface is again washed. This surface washwater is stored in the same lagoon as the first surface wash water. The starch is then removed in large cakey chunks to the subsurface hot air heated concrete pad for spreading and drying. After drying, it is packed and market.

2.1.2 Characteristics of the wastewater Table 1 shows the physical and chemical characteristics of tapioca starch wastes from first-grade plants studied by previous investigators. The wastewaters flow ranged from 30 to 50 m^3/ton starch with the BOD_5 from 4000 to 6000 mg/l. The pollution load of a 60 tons starch/day mill would have a population equivalent of 180,000.

Characteristics of the wastewaters from the second-grade tapioca plant are presented in table 2. The average capacity of the plant is 30 tons roots/day of 14 working hours.

2.2 Treatment of Tapioca Starch Wastes

JESUITAS (1966) carried out an investigation of tapioca starch wastes from the S.R. Tapioca Co.,Ltd. Chonburi. He studied flow and characteristics of the wastewaters and technical feasibility of the treatment using methods such as plain sedimentation, chemical coagulation, wedge-wire filtration, and aerobic treatment. The experimental results showed that plain sedimentation could remove 94 per cent of suspended solids,

Table 1 First Grade Tapioca Plant Wastewater Characteristics

Item	Units	JESUITAS (1966)	THONGKASAME (1968)	UDDIN (1970)	USUK (1975)
Temperature	°C	28.5-33.0	30-31	29.5-32.1	23-26
pH	-	3.4-4.2	3.8-5.2	4.1-4.4	3.5-3.9
Alkalinity	mg/l as $CaCO_3$	0	0	0	-
Acidity	mg/l as $CaCO_3$	667.5-860.2	135-1010	550-900	-
Suspended Solids	mg/l	1480-8400	1970-3850	2160-3450	3200-4000
Settleable Solids	ml/l	60-200	48-115	42-115	30-70
Total Solids	%	0.56-0.93	0.60-0.80	5480-6820	1500-2500
Volatile Solids	% of T.S.	92.0-98.6	80.2-86.8	78.3-89.1	0.80-0.88
Dissolved Oxygen	mg/l	0	0	-	-
BOD	mg/l	3000-4400	5550-7400	5060-6590	4500-6000
COD	mg/l	3100-13900	13800-19500	7500-15200	5500-6700
Ammonia - N	mg/l	0-4.70	0	5.0-10.2	0-4.5
Organic - N	mg/l	19.0-38.9	86-115	0.75-145	100-180
Nitrite - N	mg/l	0	0	-	-
Nitrate - N	mg/l	0	0	-	-
Phosphorus	mg/l $PO_4^{\equiv}$	5.6-8.5	0	5.0-10.0	7-14

Table 2 Second-Grade Tapioca Plant Wastewater Characteristics(Mc GARRY et.al.,1972)

Characteristics	Units	Amphur Sriracha Plant				Amphur Muang Plant I				Amphur Muang Plant II				Average
		A	B	D	Total	A	B	C	Total	A	B	C	Total	
Flow	l/kg root	1.43	6.8	0.5	8.7	0.379	4.22	0.525	5.1	0.372	4.27	0.508	5.2	6.3
BOD	mg/l	1,290	6,600	4,200	5,140	1,790	6,830	1,970	5,990	2,460	6,600	2,450	5,835	5,655
Total Solids	mg/l	2,913	15,012	4,460	12,468	4,408	11,004	3,712	9.815	7,012	10,292	3,742	9,320	10,534
T. Susp. Solids	mg/l	2,185	12,280	1,152	10,023	2,496	2,650	2,540	2,640	1,762	2,650	2,540	2,550	5,071
T. Vol. Solids	mg/l	1,823	11,276	2,992	9,285	2,243	6,008	1,529	5,295	3,148	5,856	2,069	5,240	6,606
pH	-	-	-	-	-	6.2	6.7	4.8	6.5	5.6	5.2	4.1	5.1	5.8

67 per cent of BOD_5, and 72 per cent of COD. It was also feasible to treat settled separator wastes by a biological method. Wedge-wire filtration produced a poor quality effluent. Chemical coagulation also produced poor quality effluent at high operation cost. He recommended that primary sedimentation followed by a biological process were neccessary for treatment of this particular wastes.

TONGKASAME (1968) studied unheated anaerobic treatment of tapioca starch wastes in closed digesters and in stabilization ponds. He found that the efficiency of the digestion process increased with the increase in liquid detention time. An optimum detention period was found to be about 16 days resulting in volatile solids removal of 71.8 per cent or 305 lb/acre-day and BOD removal of 71.5 per cent or 362 lb/acre-day. However, the effluents released from the ponds or the digesters were still too high in BOD and suspended solids to be discharged into a watercourse. He recommended that the effluents should be further treated using a series of ponds, including aerobic stabilization ponds, prior to final disposal.

UDDIN (1970) studied the variables influencing anaerobic pond performance. He utilized the results obtained from his study to determine the maximum areal BOD removal in single-stage anaerobic ponds and the efficiency of multi-stage pond systems. He concluded that BOD loading was the most significant variable. An optimum BOD loading for single-stage anaerobic ponds was found to be 6,000 lb/acre-day with 58 per cent BOD removal (Figure 3). Areal BOD removals in the second and third-stage ponds were less than that obtained in the first-stage anaerobic ponds with equal detention time. The three stages of anaerobic ponds in series gave an average total BOD removal of 84.0 percent at an average BOD loading of 2270 lb/acre-day based on the total area. He suggested a possible lay-out of anaerobic-facultative pond system. The system for a 1 mgd. flow consisted of five stages of 3 ft. deep anaerobic ponds covering a total area of 10.2 acres followed by a final stage 8.5 acres facultative pond. He asserted that the design could give a BOD removal approaching 99 percent for a raw tapioca starch wastes having a BOD concentration of 3800 mg/l.

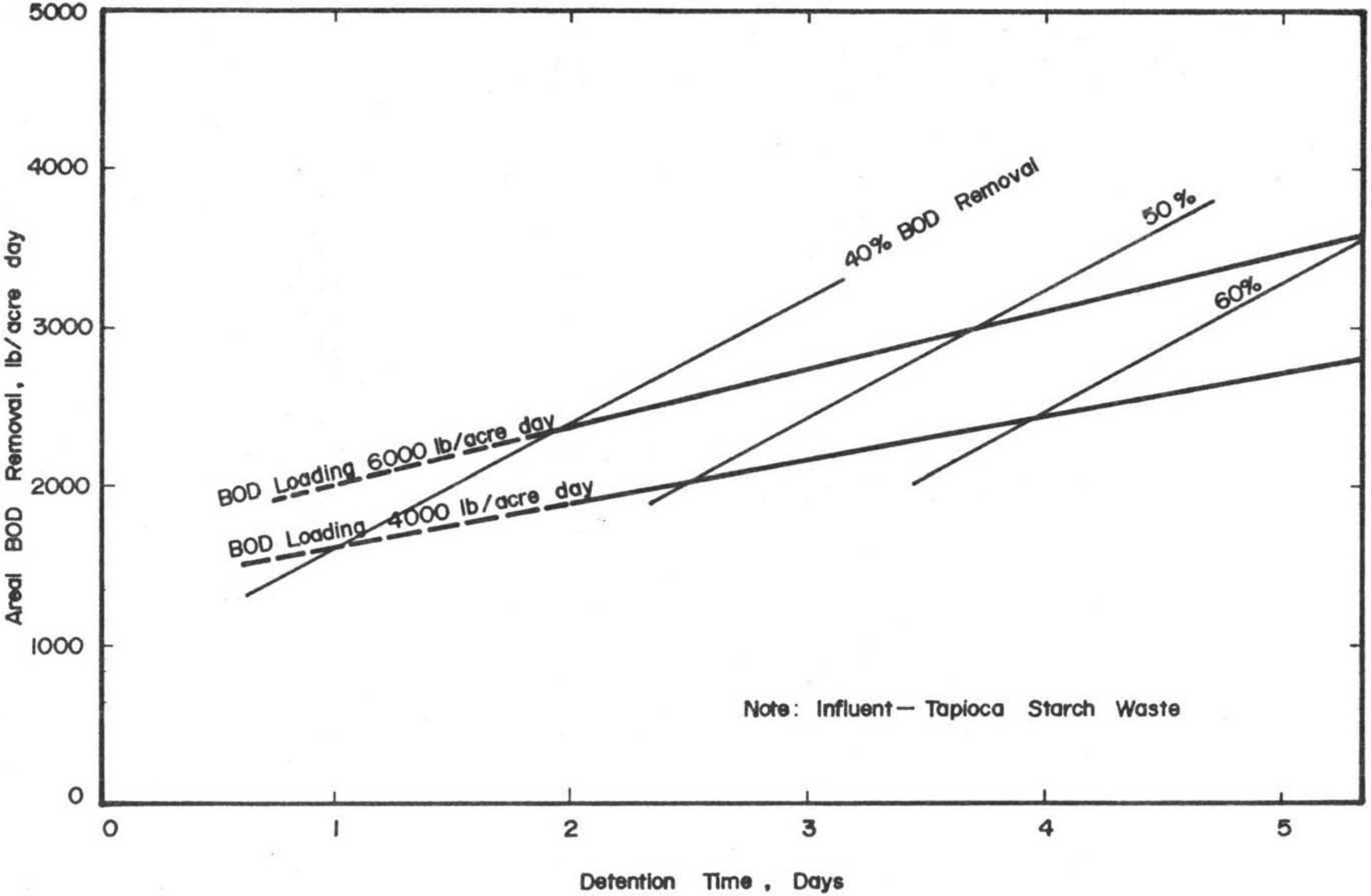

FIGURE 3. EFFECT OF DETENTION TIME ON SINGLE-STAGE ANAEROBIC POND PERFORMANCE

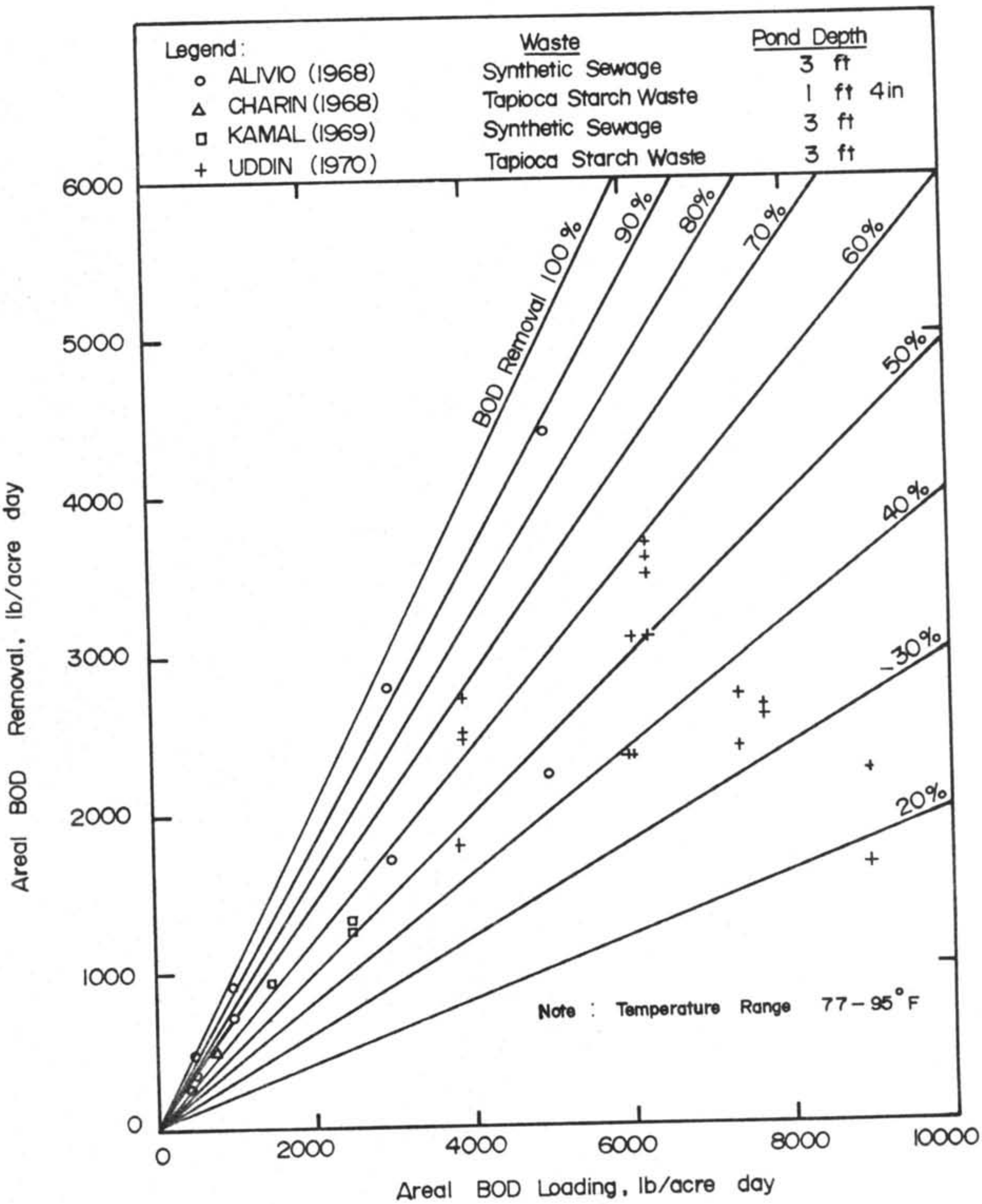

FIGURE 4 — PERFORMANCE OF EXPERIMENTAL ANAEROBIC PONDS
(AFTER Mc GARRY & PESCOD)

McGARRY and PESCOD (1970) collected and analysed the data studied by previous investigators at the Asian Institute of Technology. Figure 4 showed very high areal BOD removals which could be achieved under controlled operating conditions. They believed that at any particular detention period high BOD loadings would give higher areal BOD removals than low BOD loadings.

USUK (1975) conducted a feasibility study of tapioca starch waste treatment using a laboratory-scale activated sludge unit. He found that 90 percent BOD removal was possible at a food-to-microorganism ratio as high as 1.0 but at the expence of excessively high sludge volume to be disposed of.