

**Table 8. Vacuum filter performance for processing municipal sludges conditioned by ferric chloride and lime.<sup>a</sup>**

Type of Sludge	Solids Loading (lb/hr-ft <sup>2</sup> )	Percent Solids Cake
Fresh primary	6-8	25-38
Fresh primary and waste activated sludge	4-5	16-25
Fresh primary and waste activated sludge (pure oxygen)	5-6	20-28
Fresh primary and trickling filter humus	4-6	20-30
Digested primary (anaerobic)	5-8	25-32
Digested primary and waste activated sludge (anaerobic)	4-5	14-22

<sup>a</sup> Adapted from The EPA, Sludge Treatment and Disposal, FPA Process Design Manual Washington, D.C., 1979.

### 3.4.4 Centrifugation

Sludge centrifugation for dewatering purposes is the same as for the sludge thickening process. The sludge is fed into a rotating solid bowl centrifuge where it is centrifuged and collected on the inner wall of the bowl. The percentage of dry solids in the sludge cake removed range from 10-30%, depending on the previous processes used before dewatering (Reynolds and Richards 1996).

Once the treatment is performed to produce the end products of effluent water and biosolids, the specific question of "What to do with it now?" arises. The water effluent is usually treated with chlorine or UV light as a final disinfection step before being returned to the receiving waters or applied to agricultural land. The nature of the conditioned biosolids poses greater disposal concerns than that of the water.

## 4.0 CHARACTERIZATION

As was stated earlier, a variety of combinations of processes can be used to treat wastewater and the choice of systems is dependent on the individual need of the plant. One difficulty resulting from different unit processes is the ability to accurately characterize the sludge at different points in the system. This section will present nutrient and metal quantities as well as physical characteristics of biosolids produced from various processes.

Biosolids are comprised of three major components; dead organic cell mass from microbes and bacteria, decomposed organic solids and inert material. Table 9 shows nutrient levels found in wastewater biosolids subjected to different treatment processes (Stein, et al., 1995). The actual amount of biosolids produced in a treatment facility is dependent on many operational parameters, a few of which include temperature, mixing, recirculation, velocity, flow and detention time. These parameters are set by the operator to promote efficient operations of the processes. Table 10 presents characteristics of biosolids from different unit processes that are commonly used.

#### **4.1 Part 503**

As a result of the United States Government amending the Clean Water Act in 1987, the U.S. Environmental Protection Agency (EPA) developed a new regulation to protect public health and the environment from any reasonably anticipated adverse effects of certain pollutants that might be present in biosolids. This regulation, The Standards for the Use or Disposal of Sewage Sludge (Title 40 of the Code of Federal Regulations [CFR], Part 503) was published in the Federal Register in 1993. This regulation will be referred to in this report as “Part 503”. Part 503 establishes requirements for the final use or disposal of biosolids when they are applied to land as a soil conditioner or fertilizer, placed on a surface disposal site, fired in an incinerator, or placed in a MSW landfill (Walker, 1994). The Georgia Environmental Protection Division draws upon the EPA’s Part 503 regulations as the basis for Georgia’s regulations. The EPA provides no funding for the states to take over or administer Part 503, thus making it a self-implementing responsibility for each state.

**Table 9. Nutrient levels in sewage sludge from different treatment processes.<sup>a</sup>**

Nutrient <sup>b</sup>	Sludge Treatment		Range	Median	Mean
	Process <sup>c</sup>	No. of Samples			
Organic C (%)	Anaerobic	31	18-39	26.8	27.6
	Aerobic	10	27-37	29.5	31.7
	Other	60	6.5-48	32.5	32.6
	All	101	6.5-48	30.4	31
Total N (%)	Anaerobic	85	0.5-17.6	4.2	5.0
	Aerobic	38	0.5-7.6	4.8	4.9
	Other	68	<0.1-10	1.8	1.9
	All	191	<0.1-17.6	3.3	3.9
NH <sub>4</sub> <sup>+</sup> -N (mg/kg)	Anaerobic	67	120-67,600	1600	9,400
	Aerobic	33	30-11,300	400	950
	Other	3	5-12,500	80	4,200
	All	103	5-67,600	920	6,540
NO <sub>3</sub> <sup>-</sup> -N	Anaerobic	35	2-4,900	79	520
	Aerobic	8	7-830	180	300
	Other	3	-	-	780
	All	45	2-4,900	149	490
Total P (%)	Anaerobic	86	0.5-14.3	3	3.3
	Aerobic	38	1.1-5.5	2.7	2.9
	Other	65	<0.1-3.3	1.0	1.3
	All	189	<0.1-14.3	2.3	2.5
K (%)	Anaerobic	86	0.02-2.64	0.3	0.52
	Aerobic	37	0.08-1.10	0.39	0.46
	Other	69	0.02-0.87	0.17	0.20
	All	192	0.02-2.64	0.3	0.40
Na (%)	Anaerobic	73	0.01-2.19	0.73	0.70
	Aerobic	36	0.03-3.07	0.77	1.11
	Other	67	0.01-0.96	0.11	0.13
	All	176	0.01-3.07	0.24	0.57
Ca (%)	Anaerobic	87	1.9-20	4.9	5.8
	Aerobic	37	0.6-13.5	3.0	3.3
	Other	69	0.12-25	3.4	4.6
	All	193	0.1-25	3.9	4.9

<sup>a</sup> Adapted from Stein (1994).

<sup>b</sup> Concentration and percent composition are on a dried solids basis

<sup>c</sup> "Other" includes lagooned, primary, tertiary, and unspecified sludges.

"All" signifies data for all types of sludges

**Table 10. Typical quantities of sludge produced by different unit processes.<sup>a</sup>**

Unit Processes	Typical Quantity of Sludge			Moisture (%)	Specific Gravity of Sludge Solids	Specific Gravity of Sludge	Dry Solids	
	gal/MG of Waste-water	tons/MG of Waste-water	ft <sup>3</sup> /1000 persons				lb/MG of Waste-water	lb/1000 persons daily
Primary Sedimentation:								
Undigested	2,950	12.5	39	95	1.4	1.02	1,250	125
Digested in separate tanks	1,450	6.25	19	94	-	1.03	750	75
Digested & dewatered, sand beds	-	0.94	5.7 <sup>d</sup>	60	-	-	750	75
Digested & dewatered, vacuum filters	-	1.36	4.3	72.5	-	1.00	750	75
Trickling Filter <sup>c</sup>	745	3.17	9.9	92.5	1.33	1.025	476	48
Chemical Precipitation:								
Dewatered on vacuum filters	-	6.00	19.3 <sup>e</sup>	72.5	-	-	3,300	330
Primary Sedimentation & Act. Sludge:								
Undigested	6,900	29.25	92	96	-	1.02	2,340	234
Undigested & dewatered, vacuum filter	1,480	5.85	20	80	-	0.95	2,340	234
Digested in separated tanks	2,700	11.67	36	94	-	1.03	1,400	140
Digested & dewatered, sand beds	-	1.75	18 <sup>f</sup>	60	-	-	1,400	140
Digested & dewatered, vacuum filters	-	3.50	11.7	80	-	0.95	1,400	140
Activated Sludge <sup>b</sup> :								
Wet Sludge	19,400	75.0	258	98.5	1.25	1.005	2,250	225
Dewatered on vacuum filters	-	5.62	19	80	-	0.95	2,250	225
Dried by heat dryers	-	1.17	3	4	-	1.25	2,250	225
Septic Tanks, digested:	900	-	12	90	1.4	1.04	810	81

<sup>a</sup> Adapted from ASCE & WPCF (1977),

Wastewater flow of 100 gpcd (378.5 l/person d) and 300 mg/L, or .25 lb/day/cap of suspended solids in wastewater.

Sludge produced varies according to type and extent of industrial connections, collection system, & plant location.

<sup>b</sup> Raw wastewater discharge directly to aeration tanks

<sup>c</sup> With secondary sedimentation

<sup>d</sup> Based on density of 33 lb/cu ft (530 kg/m<sup>3</sup>)

<sup>e</sup> Based on density of 62 lb/cu ft (1000 kg/m<sup>3</sup>)

<sup>f</sup> Based on density of 19 lb/cu ft (305 kg/m<sup>3</sup>)

One major concern when focusing on the potential reuse capability is the metals content of the biosolids. Part 503 sets a ceiling for metals concentration in biosolids that are going to be used on the land in one form or another as shown in Table 11. A description of the potential reuse methods used in Georgia will be discussed in the next section; Current Biosolids Management Practices.

**Table 11. Pollutant limits.<sup>a</sup>**

Pollutant	Ceiling Concentration Limits for all Biosolids Applied to Land (mg/kg) <sup>b</sup>	Pollutant Concentration Limits for EQ <sup>d</sup> and PC <sup>e</sup> Biosolids (mg/kg)
Arsenic	75	41
Cadmium	85	39
Chromium	3,000	1,200
Copper	4,300	1,500
Lead	840	300
Mercury	57	17
Molybdenum	75	- <sup>c</sup>
Nickel	420	420
Selenium	100	36
Zinc	7,500	2,800
Applies to: From Part 503	All biosolids that are land applied Table 1, Section 503.13	Bulk biosolids and bagged biosolids <sup>f</sup> Table 3, Section 503.13

<sup>a</sup> Adapted from Walker (1994)

<sup>b</sup> Dry weight basis

<sup>c</sup> As a result of the Feb 25, 1994, Amendment to the rule, the limits for molybdenum were deleted from the Part 503 rule pending EPA reconsideration

<sup>d</sup> EQ: Exceptional Quality

<sup>e</sup> PC: Pollutant Concentration

<sup>f</sup> Bagged biosolids are sold or given away in a bag or other container

All wastewater facilities monitor their biosolids to ensure compliance with this regulation. The EPA's 1990 National Sewage Sludge Survey (NSSS) analyzed samples of 412 pollutants or analyses from 177 POTW's using at least secondary treatment processes, including the ten metals regulated by Part 503 (Stein, Boulding et al., 1995). Table 12 shows the average sludge concentrations of each of Part 503 pollutants.

Biosolids are categorized by quality as they relate to disposal methods. The solids are classified as being either Excellent Quality (EQ), class A or class B. Class A and B refers to the Part 503 pathogen standards that must be met at the time of application or disposal. The EQ biosolids have nearly undetectable pathogen levels, controlled vector conditions, low metal content and stable organic material so there is little odor. EQ material can be sold or applied to land without any site restrictions. Class A biosolids have very low pathogens and typically low metals concentrations, however, as it stands Part 503 only requires that metals be below the ceiling concentration limits.

**Table 12. Mean concentrations of metals in sewage sludge compared to Part 503 ceiling concentration limits.<sup>a</sup>**

Metal	Mean Concentration (mg/kg, DW)	Part 503 Pollutant Ceiling Concentration Limits (mg/kg,DW)
Arsenic	9.9	75
Cadmium	6.94	85
Chromium	119	3000
Copper	741	4300
Lead	134.4	840
Mercury	5.2	57
Molybdenum	9.2	75
Nickel	42.7	420
Selenium	5.2	100
Zinc	1202	7500

<sup>a</sup> Adapted from Stein (1994)

EPA's 1990 National Sewage Sludge Survey (NSSS) analyzed samples of 412 pollutants or analytes from 177 POTW's using at least secondary treatment processes, including the 10 metals regulated by Part 503 for land application.

Class B biosolids have higher pathogen contents than Class A, but pathogens are reduced to levels not likely to pose a threat to public health and the environment under specific use conditions (Stein, et al., 1995). There could be possible problems with vector disturbances if proper management practices are not implemented. There are agricultural land application restrictions in place for class B to minimize the interaction that humans and animals can have with the land applied biosolids until possible pathogen levels are reduced to below detectable levels. Class B solids, requiring a site permit, have considerable restrictions on the type of human food crops that can be planted and on the planting times after application. Again, metals content of Class B biosolids are typically low but only requirement is to be below ceiling threshold. Biosolids that do not reach Class B standards cannot be applied to land without further treatment since it does not meet the pathogen, metal, or vector reduction standards. Table 13 summarizes the classification requirements for land application biosolids classes.

**Table 13. Regulatory classifications for land applied biosolids.**

	<b>Exceptional Quality</b>	<b>Class A</b>	<b>Class B</b>
Metals <sup>a</sup>	Low	Low or Medium	Low or Medium
Pathogens <sup>b</sup>	Low	Low	Medium
Vector Attraction	Low	Low	Low
Odor	Low	Low	Low
Permits	None	Yes	Yes
Fertilizer	Yes	Yes	Yes
Soil Amendment	Yes	Yes	Yes
Marketable	Yes	Yes	No

<sup>a</sup> Low- Below EPA Table 3 Pollutant Concentrations

Medium- Between EPA Table 1 Ceiling Concentration Limits & Table 3 Pollutant Concentrations

<sup>b</sup> Low is <1,000 MPN/g TS

Medium is <2,000,000 MPN/g TS

(MPN/g TS = Most Probably Number per gram of Total Solids)