DADIINSTITUTEOFENGINEERINGANDTECHNOLOGY

(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)

NAACAccreditedInstitute

RecognizedbyUGC2(F)and12(B)

AnISO9001:2008,14001:2004&OHSAS18001:2007CertifiedInstituteNH–16,Anakapalle, Visakhapatnam–531002,AndhraPradesh

DEPARTMENTOFCIVILENGINEERING

COURSEFILE

NameoftheCourse: EnvironmentalEngineering-II **ClassandBranch:**IIIB.Tech,Civil

Department: CivilEngineering **AcademicYear:**2019-20

Prepared by Course Instructor Name : Mr B.Seshagiri Rao. Designation: Assistant Professor Signature : Date:
Reviewed by Course Co- OrdinatorName : Designation:Signa ture : Date:
Reviewed by Module Co- OrdinatorName : Designation:Signa ture : Date:
Reviewed by Program Co- OrdinatorName : Signature : Date:
Reviewed by HODName : Signature : Date:
Approved by Academic ConvenerName : Signature :Date :

COURSEFILECONTENTS

1. Vision and Mission of the Institute and Department
2. Syllabus of the Course (as per JNTU Kakinada Regulations)
3. Additional Reference Books, Journals, websites and E-links
4. GapsintheSyllabustoMeetIndustryRequirements(ifany)
5. CourseHandout

Part A-Course Description,Course Objectives, Course Out comes, Course Articulation Matrix
PartB-CourseDelivery Plan(LessonPlan)withTLMs
PartC-TeachingLearningMethods,AcademicCalendarandEvaluationProcess

6. PEOsandPOs
7. ListoftheStudentsoftheClass withRollNumbers
8. ClassTime TableandIndividualTimeTable
9. TutorialQuestions(Unitwise)
10. AssignmentQuestions(Unit wise)
11. QuizQuestions/ObjectivetypeQuestions(Unit wise)12.QuestionBank(DescriptiveQuestionswithBLOOMSTaxonomy)

13.PreviousUniversityQuestionpapers(MinimumFive)14.GATE Questions (Unit wise)

15.Campus Placement Questions(Unit wise)16A.Internal(Mid)ExaminationsQuestionPapers

16B.FirstMidInternalMarksofrespective Subject,MidMarksAnalysisandActionTakenReport

16C.SecondMidInternalMarksofrespectiveSubject,MidMarksAnalysisandActionTaken Report

17. Detailednotes(Unitwise)
18. QualitymeasurementSheets
19. CO-POAttainmentProcess(asper thesuggestionofNBACo-Ordinator)
20. ClosureReportoftheCourse/CourseReview

Annexures:

(SuggesttheCourseInstructortoattachtheAnnexuresattheendoftheCourseFile)

1.Academic Calendar declared by JNTU Kakinada(and our Institution)2.FirstMidTimeTabledeclaredbyJNTUKakinada(andourInstitution)

3.SecondMidTimeTabledeclaredbyJNTUKakinada(andourInstitution)4.End Examinations Time Table declared by JNTU Kakinada5.ExaminationsResultsdeclaredbyJNTUKakinada

6. ExaminationsResultsAnalysispreparedbyourInstitutionExamCell
7. Re Counting/Re Valuation Results declared by JNTU Kakinada8.ExaminationsResultsAnalysis prepared by our Institution after RC/RV Results9A.RemedialClassesinformationwithnecessaryProofs(Listofstudents,date,Topicetc)9B.BacklogClassesinformationwithnecessaryProofs(Listofstudents,date,Topicetc)
10. MinutesofCourseCo-OrdinatorandModuleCo-Ordinator

1. VisionandMissionoftheInstituteandDepartmentVisi

onoftheInstitute

ToevolveintoaPremierTechnicalInstitutionwithValuebasedEducationtonurtureCompetitive TechnologiststoBuildNewWorld.

MissionoftheInstitute

To Promote Personality Development, Academic Excellence, Creative Technology, Disciplined Career,HumanService,EthicalValues&IndianCultureforenlightenmentoftheGlobalSociety.

Vision oftheDepartment

To impart knowledge and excellence in Civil Engineering with innovative perspectives to the studentcommunityandmakethemstrongEngineersethicallyforbuildingastrongnation.

MissionoftheDepartment

- TopromoteinnovativeideaswithoriginalthinkinginthemindsofbuddingEngineerstofacethefuturechallenges.
- Toprovideknowledgebaseandconsultancyservicestothecommunityinall areasofCivilEngineering.
- ToproduceCivilEngineers ofhigh caliberwith advancedtechnicalskillsand ethicalvaluesto servethesocietyandthenation.
- TomaketheDepartmentasacentreofexcellenceinthefieldofCivilEngineeringandalliedresearchactivities.

2. SyllabusoftheCourse

IV YearB.TechCE-I Semester		L	T	P	C
		3	0	0	3
EnvironmentalEngineering-II					

UNIT – I: Introduction to Sanitation – Systems of sanitation – relative merits & demerits – collection and conveyance of wastewater – sewerage – classification of sewerage systems- Estimation of sewage flow and storm water drainage – fluctuations – types of sewers - Hydraulics of sewers and storm drains– design of sewers

UNIT – II: Sewer appurtenances – cleaning and ventilation of sewers. Pumping of wastewater: Pumping stations – location – components– types of pumps and their suitability with regard to wastewaters. House Plumbing: Systems of plumbing-sanitary fittings and other accessories– one pipe and two pipe systems – Design of drainage in Gate communities, Apartments and Hotels.

UNIT – III: Sewage characteristics – Sampling and analysis of wastewater - Physical, Chemical and Biological Examination-Measurement of BOD and COD – BOD equations. ThOD and Nirogen Oxygen Demand. Ultimate Disposal of sewage: Methods of disposal – disposal into water bodies-Oxygen Sag Curve- Disposal into sea, disposal on land, Crown corrosion, Sewage sickness. Effluent standards.

UNIT – IV: Treatment of Sewage: Primary treatment- Screens- Grit chambersGrease traps– floatation– Sedimentation – Design of preliminary and primary treatment units. Secondary treatment: Aerobic and anaerobic treatment processcomparison. Suspended growth process: Activated Sludge Process, principles, designs, and operational problems, modifications of Activated Sludge Processes, Oxidation ponds, Aerated Lagoons. Attached Growth Process: Trickling Filters – mechanism of impurities removal – classification – design, operation and maintenance problems.RBCs, Fluidized bed reactors.

UNIT V: Miscellaneous Treatment Methods: Nitrification and DenitrificationRemoval of Phosphates – UASB– Membrane reactors- Integrated fixed film reactors. Anaerobic Processes: Septic Tanks and Imhoff tanks- working Principles and Design– Reuse and disposal of septic tank effluent, FAB Reactors. Bio-solids (Sludge) management: Characteristics-SVI, handling and treatment of sludge-thickening – anaerobic digestion of sludge, Sludge Drying Beds. Centrifuge.Case studies.

TextBooks

1. WastewaterEngineering TreatmentandReuse,Metcalf&Eddy,TataMcGraw-Hilledition.
2. IndustrialWaterandWastewaterManagement,K.V.S.G.Murali Krishna.
3. ElementsofEnvironmentalEngineering,K.N.Duggal,S.Chand&CompanyLtd.NewDelhi,2012.

References

4. EnvironmentalEngineering,HowardS.Peavy,DonaldR.Rowe,TeorgeGeorgeTchobanoglus–Mc-Graw-HillBookCompany,NewDelhi,1985
5. WastewaterTreatment forPollutionControlandReuse,Soli.JArceivala, ShamRAsolekar,Mc-GrawHill,NewDelhi;3rdEdition
6. Environmental Engineering –II: Sewage disposal and Air Pollution Engineering, Garg, S. K., Khanna Publishers7.Sewagetreatmentanddisposal,P.N.Modi &Sethi.
8.EnvironmentalEngineering,RuthF.WeinerandRobinMatthews–4thEditionElsevier,2003EnvironmentalEngineering,D.Srinivasan,PHILearningPrivateLimited,New2011

3.AdditionalReferenceBooks,Journals,websitesandE-links

ReferenceBooks:

1.Sk.Garg,EnvironmentalEngineering Vol1,Vol2

websitesandE-links:

1.https://www.open.edu/openlearncreate/mod/oucontent/view.php?id=80395&printable=1
2.https://www.slideshare.net/gauravhtandon1/pumping-stations3.http://www.fao.org/3/t0551e/t0551e03.htm
4.https://www.youtube.com/watch?v=pvkzltheDAk
5.https://www.youtube.com/watch?v=sW5j775s_hw
6.https://en.wikipedia.org/wiki/Sewage_treatment

4.GapsintheSyllabustoMeetIndustryRequirements(ifany)

- Aspertheindustrylevelsthefollowingaretheknowngapsofthe subjectwhichisintheJNTUcurriculum.
- .The________subjectasperthecurriculumisnotmatchingwiththe______________________
- Thesubjectisnotmatchingwithrealtimeapplications

5. CourseHandout

DADIINSTITUTEOF ENGINEERINGANDTECHNOLOGY

(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)

NAACAccreditedInstitute

An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified InstituteNH–16,Anakapalle,Visakhapatnam–531002, AndhraPradesh

DEPARTMENTOFCIVILENGINEERING

COURSEHANDOUT

Part – A

(CourseDescription,CourseObjectives,CourseOutcomes,CourseArticulationMatrix)

PROGRAM :B.Tech,Civil
CLASSandSemester :IVB.TechI-Sem,CivilEngineering
ACADEMICYEAR : 2019-20
COURSENAME&CODE :EnvironmentalEngineering-II
L-T-PSTRUCTURE :3-0-0
COURSECREDITS : 3
COURSEINSTRUCTOR : Mr.B.Seshgiri Rao
COURSECOORDINATOR : Mr.B.Seshgiri Rao
PRE-REQUISITE :EnvironmentalEngineering-II

COURSE DESCRIPTION : This course provides the knowledge on the issues related to the **Environment**.It mainly deals with Environment based subjects like pollution(Water), industrial hygiene, hazardous wastemanagement.

COURSEOBJECTIVES

Thestudentwillbeableto

- Outlineplanningandthedesignofwastewatercollection,conveyanceandtreatmentsystemsforacommunity/town/city
- Provideknowledgeofcharacterisationofwastewatergeneratedinacommunity
- Impartunderstandingoftreatmentofsewageandtheneedforitstreatment.
- Summarizetheappurtenanceinseweragesystemsandtheirnecessity
- Teachplanning,anddesignofseptictankandimhofftankandthedisposaloftheeffluentfromtheselowcosttreatmentsystems
- Effluentdisposalmethodandrealisetheimportanceofregulationsinthedisposalofeffluentsinrivers

COURSEOUTCOMES(COs)

Aftergoingthroughthiscoursethestudentwillbeableto

- Plananddesigntheseweragesystems
- Design of Plumbing for an apartment, Gated community or Hotels or Individual houses and Select the appropriate appurtenances in the sewerage systems
- Estimation of BOD and COD and Suggest a suitable disposal method with respect to effluent standards, and Identify the critical point of pollution in a river for a specific amount of pollutant disposal into the river
- Analyze sewage and design suitable treatment system for sewage treatment for a village/City.
- Design of sewage treatment systems like Septic tank soak pit system and FAB reactor for buildings and understanding tertiary treatment of sewage.

COURSEARTICULATIONMATRIX(CorrelationbetweenCos&POs,PSOs):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	-	-	-	-	-	-	-	-	-	-	1	1	-
CO2	2	2	2	-	-	-	-	-	-	-	-	2	2	-
CO3	2	2	3	-	-	-	-	-	-	-	-	2	3	-
CO4	1	1	-	-	-	-	-	-	-	-	-	1	2	-

1:Slight(Low) 2:Moderate(Medium) 3:Substantial(High) -:None

DADIINSTITUTEOFENGINEERINGANDTECHNOLOGY

(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)

NAACAccreditedInstitute

An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified

InstituteNH–16,Anakapalle,Visakhapatnam–531002,AndhraPradesh

DEPARTMENTOFCIVILENGINEERING

Part –B

COURSEDELIVERYPLAN

NameoftheCourse: EnvironmentalEngineering-II **Class&Branch:**IV B.TechI Sem

AcademicYear :2021-2022 **Regulation** :R16

FacultyName : Mr.B.Seshgiri Rao **Designation** : AssistantProfessor

S.No.	Topic	No. of periods required	Teaching Learning Method	Proposed date of completion	Actual date of completion	HOD Review
	UNIT – 1					
1.	Introduction of Sanitation	1	TLM 2			
2.	Terminology used in Sanitation-Necessity	1	TLM 2			
3.	Systems Of Sanitation	1	TLM 2			
4.	Relative Merits & Demerits	1	TLM 2			
5.	Collection And Conveyance Of Waste Water	1	TLM 2			
6.	Sewerage, Classification Of Sewerage Systems	1	TLM 2			
7.	Estimation Of Sewage Flow And Storm Water Drainage	1	TLM 2			
8.	Types Of Sewers,	1	TLM 2			
9.	Design Of Sewers	1	TLM 4			
10.	Tutorial-1	1	TLM 3			
	UNIT- 2					
11.	Introduction					
12.	Apppurtences in sewer	1	TLM 2			
13.	Pumping Stations – Requirements	1	TLM 2			
14.	Pumps-Definition-Types	1	TLM 2			
15.	Centrifugal Pumps –Description-Design	1	TLM 2			
16.	House Plumbing	1	TLM 2			
17.	Systems Of Plumbing	1	TLM 2			
18.	Sanitary Fittings And Other Accessories	1	TLM 2			
19.	Design Of Building Drainage	1	TLM 2			
20.	Pumping Stations – Location, Components	1	TLM 2			
21.	Systems of plumbing and sanitary fittings	1	TLM 2			
22.	One pipe and two pipe systems	1	TLM 2			
23.	Design of drainage in gated communities and apartments and hotels	1	TLM 2			
24.	Tutorial-2	1	TLM 3			
	UNIT – 3					
25.	Sampling And Analysis Of Wastewater	1	TLM 2			
26.	Physical &Chemical Characteristics	1	TLM 2			
27.	Biological Examination(BOD)	1	TLM 2			
28.	Measurement Of BOD And COD	1	TLM 2			
29.	BOD Equations	1	TLM 2			
30.	Methods of disposalof sewage in water bodies	1	TLM 2			
31.	Oxygen sag curve and disposal into sea and land	1	TLM 2			
32.	Crown corrosion	1	TLM 2			
33.	Sewage sickness and Effluent standards	1	TLM 2			
34.	Tutorial-3	1	TLM 3			
	UNIT – 4					
35.	Introduction	1	TLM 1			
36.	Design of Preliminary And Primary Treatment Units	2	TLM 1			
37.	Aerobic And Anaerobic Treatment Process	1	TLM 2			
38.	Comparison Of Aerobic And Anaerobic	1	TLM 2			
39.	Suspended Growth Process	1	TLM 2			
40.	Activated Sludge Process, Principles,	1	TLM 2			
41.	Design-Problems	1	TLM 4			
42.	Modifications Of Activated Sludge Processes	1	TLM 2			
43.	Oxidation Ponds	1	TLM 2			
44.	Aerated Lagoons	1	TLM 2			
45.	Attached Growth Process	1	TLM 2			

46.	Trickling Filters–Mechanism Of Impurities	1	TLM 2			
47.	Design-Operation And Maintenance Problems	1	TLM 2			
48.	Fluidized Bed Reactors	1	TLM 2			
49.	Tutorial-4	1	TLM 3			
	UNIT – 5					
50.	Miscellaneous Treatment Methods	1	TLM 1			
51.	Nitrification	1	TLM 1			
52.	De Nitrification	1	TLM 1			
53.	Removal Of Phosphates	1	TLM 2			
54.	UASB&Membrane Reactors	1	TLM 2			
55.	Integrated Fixed Film Reactors&Anaerobic Processes	1	TLM 2			
56.	Septic Tanks And Imhoff Tanks	1	TLM 2			
57.	Principles And Design Of Anaerobic	1	TLM 1			
58.	Disposal of Septic Tank Effluent&FAB Reactors	1	TLM 2			
59.	Introduction to Bio solids	1	TLM 4			
60.	Characteristics	1	TLM 2			
61.	Handling And Treatment Of Sludge	1	TLM 2			
62.	Thickening	1	TLM 1			
63.	Anaerobic Digestion Of Sludge	1	TLM 1			
64.	Sludge Drying Beds	1	TLM 1			
65.	Tutorial-5	1	TLM 3			

TotalNo.ofclassesRequiredtocompletethesyllabus:66

CourseInstructor **CourseCoordinator** **ModuleCo-Ordinator** **ProgramCo-Ordinator** **HOD**

DEPARTMENTOFCIVILENGINEERING

Part –C

NameoftheCourse: EnvironmentalEngineering-II **Class&Branch:**IVB.TechI Sem
AcademicYear :2019-2020 **Regulation** :R16

TeachingLearningMethods			
TLM1	ChalkandTalk	**TLM5**	ActivitybasedLearning
TLM2	LCDProjector	**TLM6**	Flipped//BlendedLearning
TLM3	Tutorial(ProblemSolving)	**TLM7**	ExperientialLearning
TLM4	ParticipatoryLearning	**TLM8**	ProjectBasedLearning

ACADEMICCALENDAR:

Description	**From**	**To**	**Weeks**
IPhaseofInstructions-1			7W
IMidExaminations			1W
IIPhaseofInstructions			7W
IIMidExaminations			1W
PreparationandPracticals			1W
SemesterEndExaminations			2W

EVALUATIONPROCESS:

EvaluationTask	**COs**	**Marks**
FirstMidExamination	1,2,3	M1=15
FirstOnlineExamination	1,2,3	OL1=10
FirstAssignment	1,2,3	A1=5
FirstMidMarksTotal(X1)=M1+OL1+A1	1,2,3	X1=30
SecondMidExamination	4,5,6	M2=15
SecondOnlineExamination	4,5,6	OL2=10
SecondAssignment	4,5,6	A2=5
SecondMidMarksTotal(X2)=M2+OL2+A2	4,5,6	X2=30
CumulativeInternalExaminationMarks(X):(80%ofHighest+80%of Lowest)	1,2,3,4,5,6	X=30
SemesterEndExaminations	1,2,3,4,5,6	Y=70
TotalMarks:X+Y	1,2,3,4,5,6	100

CourseInstructor **CourseCoordinator** **ModuleCo-Ordinator** **Program Co-Ordinator** **HOD**

6. PEOsandPO's

ProgramEducationalObjectives

ProgramEducationalObjectivesoftheUGCivil Engineeringare:

PEO1: Provide Engineering design solutions for the real world problems in Structures, Environmental, Geotechnical,Constructional planning and techniques, Water resources,Remote Sensing and Transportation EngineeringdomainsofCivil Engineering.
PEO2: Theywillsucceedandexcelintheirchosenprofessionalpractice/researchandenroll/pursuehighereducationintherep utedInstitutionsofIndiaandAbroad fromthefieldofCivil Engineering.
PEO3: Makeethicaldecisionsanddemonstratea commitmenttotheprofessionbodiesandsociety.
PEO4: Acquireapositionthatvaluesadaptabilityandinnovationintheirprofession.
PEO5: Demonstrateleadership,bothin theirchosenprofessionandinothersocialresponsibilities.

ProgrammeOutcomes

TheProgramOutcomesofUGCivilEngineeringare:

PO 1: Engineering knowledge: Apply the knowledge of Mathematics, Science, Engineering Fundamentals, andan Engineeringspecializationtothesolutionofcomplexengineeringproblems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problemsreaching substantiated conclusions using first principles of Mathematics, Natural Sciences, and Engineeringsciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design systemcomponents or processes that meet the specified needs with appropriate consideration for the public healthandsafety,alongwithcultural,societal,andenvironmentalconsiderations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods includingdesign of experiments, analysis and interpretation of data, and synthesis of the information to provide validconclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern Engineering andIT tools including prediction and modeling to complex engineering activities with an understanding of thelimitations.

PO 6: The Engineer and society: Apply reasoning based on the contextual knowledge to assess societal, health, safety,legalandculturalissuesandtheconsequentresponsibilitiesrelevanttotheprofessionalengineeringpractice.

PO7: Environmentandsustainability:Understandtheimpactoftheprofessionalengineeringsolutionsinsocietalandenvironm entalcontexts,anddemonstratetheknowledgeof,andneedforsustainabledevelopment.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of theengineeringpractice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams,and inmultidisciplinarysettings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering communityand with society at large, such as, being able to comprehend and write effective reports and designdocumentation,makeeffectivepresentations, andgiveandreceiveclearinstructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the Engineering andManagement principles and apply these to one's own work, as a member and leader in a team , and tomanageprojectsinmultidisciplinaryenvironments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent andlife-longlearninginthebroadestcontext oftechnologicalchange.

POs&PSOREFERENCE:

PO1	EngineeringKnowledge	PO7	Environment&Sustainability	PSO1	
PO2	ProblemAnalysis	PO8	Ethics	PSO2	
PO3	Design&Development	PO9	Individual&TeamWork		
PO4	Investigations	PO10	CommunicationSkills		
PO5	ModernTools	PO11	ProjectMgt.&Finance		
PO6	Engineer&Society	PO12	LifeLongLearning		

<u>ProgramSpecificoutcomes</u>

PSO1: To enhance the employability skills by making the students good in codes of practice, materials, techniques andSoftwares.

PSO2: Todevelopanddesignsustainableandsmartinfrastructureconsideringtheglobalenvironmentalchallenges.

PSO 3: The graduates will be able to work effectively as an individual or in a team having acquired leadership skills andmanageprojectsinmultidisciplinaryenvironments.

7. Listofthe StudentsoftheClasswithRoll Numbers

IV B.TECH ISEMCIVIL

1	16U41A0101	BANDARU SANKAR
2	16U41A0102	CHANDRA AMUKTHA MALYADA
3	16U41A0104	GANNU PYDI RAJESH
4	16U41A0106	KORIBILLI ANIL KUMAR
5	16U41A0107	KOTNI NARESH
6	16U41A0108	PALLA PARAMESWARI
7	16U41A0109	POTHALA ARUN KUMAR
8	16U41A0110	POTNURU SAI KUMAR
9	16U41A0111	SONU KUMAR URAW
10	16U41A0112	SURISETTY INDRA NAGAPHANEENDRA
11	16U41A0113	VIYYAPU BHASKAR RAO
12	16U41A0114	PEDADA RAJ MAHESH
13	16U41A0115	SIDDA SIRISHA
14	16U41A0116	PENTAKOTA GEETHANJALI
15	17U45A0101	ALLA BABA AJAY
16	17U45A0102	BADAMPUDI RAVICHINNA
17	17U45A0103	BALIREDDI HEMANTH KUMAR
18	17U45A0104	BODDETI NAVEENA LAKSHMI
19	17U45A0105	BOTLA TARUN
20	17U45A0106	BOTTA SIVA VENKATA SAI
21	17U45A0107	CHAKKALA DURGAPRASAD
22	17U45A0108	CHUKKALA JAGADISH LOVA SAIRAM
23	17U45A0109	DEKKA RAMCHANDU
24	17U45A0110	DEVI POLAMARASETTY
25	17U45A0111	GEDUTHURI RAMYA
26	17U45A0112	GODDU ASIRINAIDU
27	17U45A0113	GUDE NANDI PRIYA
28	17U45A0114	GUNNABATTULA GAYATRI
29	17U45A0115	JAGARAPU YASWANTH
30	17U45A0116	J. SRAVANI NAGADURGA ABHAVANI
31	17U45A0117	JOMMALA VANI
32	17U45A0118	KAKARA KARTHIK
33	17U45A0119	KANDREGULA SAMPATH KUMAR
34	17U45A0120	KANDULA RAVI TEJA
35	17U45A0121	KONKUPUDI SANKAR SAI
36	17U45A0122	KOPPISETTY RAJESH
37	17U45A0123	K. ROHINI RENUKA NAGA SAILAXMI
38	17U45A0124	LALAM ANANTHA BABU
39	17U45A0125	MADDALA ANURADHA LAKSHMI
40	17U45A0126	MADDALA CHAKRAVARTHI
41	17U45A0127	MADIBOYINA MADHURI
42	17U45A0128	MAGARAPU SANTOSH KUMAR
43	17U45A0129	MANDAPAKA KISHORE
44	17U45A0130	MANNI GOVINDA KRISHNA
45	17U45A0131	MANTHINI VENKATA RAMANA
46	17U45A0132	MATHALA PRAVEEN KUMAR
47	17U45A0133	MEDISETTI BHANU PRASAD

48	17U45A0134	MUDAPAKA NAVEEN
49	17U45A0135	P. KANAKA VENKATA LAKSHMI HARIKA
50	17U45A0136	PEELA BALA SAI
51	17U45A0137	PETLA YAMINI SWETHA
52	17U45A0138	PIRADI NOOKARAJU
53	17U45A0139	POLIMERA SURYANARAYANA
54	17U45A0140	PONNAGANTI SATEESH
55	17U45A0141	SALAPU DURGA PRASAD
56	17U45A0142	SALAPU JAGADEESH
57	17U45A0143	SARAGADAM GAYATHRI
58	17U45A0144	SATHIVADA SITARAM
59	17U45A0145	SILAPARASETTI VENKATESH
60	17U45A0146	SURISETTI JAGADEESH
61	17U45A0147	SURISETTY JYOTHI
62	17U45A0148	TADI BHANU SEKHAR
63	17U45A0149	THONDA GANESH
64	17U45A0151	SILAPARASETTI JAGADEESH

8. ClassTimeTableandIndividualTimeTable

TIMINGS/DAY	09:00am-09.50am	09.50amto10.40am	10.40amto11.00am	11:00am-11:50am	11:50am-12:40pm	12.40pmto1.30pm	1:30pm-02:20pm	02:20pm-03:10pm	03:10pm-04:00pm
MON	WRE-I	SA		CT	RRB		EE-II	PM	RRB
TUE	SA	CT		PM	EE-II		SFW-II LAB/ CT LAB		
WED	EE-II	WRE-I		CT	RRB		SA	CT	WRE-I
THU	CT	SA		WRE-I	RRB		PM	EE-II	LIBRARY
FRI	WRE-I	RRB		EE-II	SA		CT LAB/SFW-II LAB		
SAT	RRB	PM		WRE-I	CT		PM	SA	SPORTS

Mrs.K.Manoharini

Day /Time	9:00 AM to10:00AM	10:00 AM to10:50AM		11:00 AM to11:50AM	11:50 AM to12:40PM		01:30PM to 2:20PM	2:20 PM to3:10PM	3:10 PM to4:00PM
Mon		EE-II	Break			Lunch	E		
Tue	EE-II				EE-II				
Wed	EE-II								
Thu							EE-II	EE-II	
Fri				EE-II			EE-II		
Sat		EE-II						EE-II	

9.TutorialQuestions(Unitwise)

DADIINSTITUTEOFENGINEERINGANDTECHNOLOGY
(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)
NAACAccreditedInstitute
An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified
InstituteNH–16,Anakapalle,Visakhapatnam–531002,AndhraPradesh

DEPARTMENTOFCIVILENGINEERING

PROGRAM : B.Tech
CE**CLASSANDSEMESTER** :IVB.Tech, I-Sem.,
CE**ACADEMICYEAR** :2019-20
COURSENAME&CODE: EnvironmentalEngineering-II
COURSEINSTRUCTOR : Mr.B.Seshgiri Rao

Tutorial–1

1. Design a sewer for a maximum discharge of 650 L/s running half full.Consider manning's rugosity coefficient n=0.012, and gradient of sewer =0.0001?
2. Explain in detailthevariousstepsinvolvedindesignofsewers?

Tutorial–2

1. Explaintypesofpumpsandtheirsuitabilitywithregardtowastewaters.-10M
2. Explainonepipeand twopipesystems?

Tutorial–3

1. DrawtheSewageTreatmentProcessand explain?
2. A 2% dilution of sewage sample is incubated for 5 days at 20^{o}C. Thedepletion of oxygenwasfoundtobe4ppm.DeterminetheBOD$_5$ofsewageat 20^{o}C.CalculateultimateBODand2dayBODat 35^{oC}andEstimate BOD$_5$@20^{o}C whose BOD$_8$@ 20^{o}C is given as 160mg/L. AssumeBOD rateconstantke=0.225d^{-1}?

Tutorial–4

1. ExplainRBCs,Fluidizedbedreactors.?
2. DesignahighrateTricklingFiltertotreat30MLDofsewage.Assumesuitablede signdata?

Tutorial–5

1. ExplainthefinalendproductsofAnaerobicprocess.Withthehelpofthesketche xplainUASB process?
2. Design single chamber septic tank to treat sewage for 60 persons. FollowprocedureasgiveninBIS2470(Codeofpracticefordesignandconstr uctionof septictanks).Drawthesketch of septictankforthedesign.Assume4personsper family?
3. ExplainCharacteristics-handlingand treatmentofsludge?

10. AssignmentQuestions(Unitwise)

DADIINSTITUTEOFENGINEERINGANDTECHNOLOGY

(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)

NAACAccreditedInstitute

An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified InstituteNH–16,Anakapalle,Visakhapatnam–531002,AndhraPradesh

DEPARTMENTOFCIVILENGINEERING

Program :IVB.TechI-Sem,CivilEngineering

AcademicYear :2019-20

CourseName&Code :EnvironmentalEngineering-II

CourseInstructor :**Mr.B.Seshgiri Rao**,AssistantProfessor

ASSIGNMENT

1UNIT-I

IntroductiontoSanitation

DateofAssignment:

1. DefineSewerage?ExplaindifferenttypesofSewarage Systems?
2. DefineSanitation?WriteaboutSystemsofSanitation?

Note: Studentshave tosubmittheAssignmentby

ASSIGNMENT

2UNIT-II

PumpingofWasteWater

DateofAssignment:

ASSIGNMENT 3

UNIT-III

SewageCharacteristics

1. Explaintypesofpumpsandtheirsuitabilitywithregardtowastewaters?
2. Explainsystemsofplumbing?
3. Explainsanitaryfittingsand otheraccessories?

Note: StudentshavetosubmittheAssignmentby

DateofAssignment:

1.ExplainPhysical,ChemicalandBiologicalExaminationandSamplingandanalysis ofwastewater?

2.DefineBODandCOD.DeriveamathematicalexpressionforfirstorderBOD.Alsodiscus sfirststage andsecondstage BOD?

Note: StudentshavetosubmittheAssignmentby

ASSIGNMENT
4UNIT-IV
SecondaryTreatment

DateofAssignment:

1.ExplainActivated Sludge Process,principles,designs,and operationalroblems,modificationsofActivatedSludge Processes?

2.ExplainTricklingFiltersandmechanismofimpuritiesremoval?

Note: Students havetosubmittheAssignmentby

ASSIGNMENT
5UNIT-V
MiscellaneousTreatmentMethods

DateofAssignment:

1.ExplainSepticTanksandImhofftanks- workingPrinciples?

2.ExplainOxygenSagCurveandExplaindisposalonland-sewagesickness?

3.Differentiateand discussthefunctioning ofSeptictank andImhofftank?

Note: StudentshavetosubmittheAssignmentby

11. QuizQuestions/ObjectivetypeQuestions(Unitwise)

DADIINSTITUTEOFENGINEERINGANDTECHNOLOGY
(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)
NAACAccreditedInstitute
An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified
InstituteNH–16,Anakapalle, Visakhapatnam–
531002,AndhraPradesh

DEPARTMENTOFELECTRONICSANDCOMMUNICATIONENGINEERING

PROGRAM **:** B.Tech
CE**CLASSANDSEMESTER** **:**IVB.Tech., I-Sem.,
CE**ACADEMICYEAR** **:**2019-20
COURSENAME&CODE: EnvironmentalEngineering-II
COURSEINSTRUCTOR **:** Mr.B.Seshgiri Rao

Date:

QuizQuestions/ObjectivetypeQuestions

UNIT-I

IntroductiontoSanitation

1. Thepollutedwaterisonewhich. [B]
(A) Containspathogenicbacteria
(B) Consistsofundesirablesubstancesrenderingitunfitfordrinkinganddomesticuse
(C) Issafeandsuitablefordrinkinganddomesticuse
(D) Iscontaminated
2. Orthotolidinetestisusedfordeterminationof[B]
(A) Dissolvedoxygen
(B) Residualchlorine
(C) Biochemicaloxygendemand
(D) Doseof coagulant
3. Thechemicalmostcommonlyusedtoincreasespeedofsedimentationofsewageis[C]
(A) Sulphuricacid
(B) Coppersulphate
(C) Lime
(D) Sodiumpermanganate
4. Thedisinfectionefficiencyofchlorineincreasesby[D]
(i) Decreasingthetimeofcontact
(ii) Decreasingthetemperatureofwater
(iii) Increasingthetemperatureofwater
(A) Only(i)
(B) Both(i)and(ii)
(C) Both(i)and(iii)
(D) Only(iii)
5. Thelayoutofdistributionsysteminwhichwaterflowstowardstheouterperipheryis[C]
(A) Ringsystem
(B) Deadendsystem
(C) Radialsystem

(D) Gridironsystem
6. Thetypeofvalvewhichallowswatertoflowinonedirectionbutpreventsitsflowinthereversedirectionis[A]
(A) Refluxvalve
(B) Sluicevalve
(C) Airreliefvalve
(D) Pressurereliefvalve
7. Thesuitablesystemofsanitationforareaofdistributedrainfall throughouttheyearwithlessintensityis[B]
(A) Separatesystem
(B) Combinedsystem
(C) Partiallyseparatesystem
(D) Partiallycombinedsystem
8. Themaindisadvantageofcementconcretesewersis[C]
(B) Difficultyinconstruction
(C) Difficultyintransportationdueto heavyweight
(D) Lesslife
9. Settlingvelocityincreaseswith[C]
(A) Specificgravityofsolidparticles
(B) Sizeofparticles
(C) Depthoftank
(D) Temperatureofliquid
10. Facultativebacteriaareabletoworkin[C]
(A) Presenceofoxygenonly
(B) Absenceofoxygenonly
(C) Presenceaswell asinabsenceofoxygen
(D) Presenceofwater
11. Thesuitablelayoutofdistributionsystemforacitywithroadsofrectangularpatternis[A]
(A) Gridironsystem
(B) Deadendsystem
(C) Ringsystem
(D) Radialsystem
12. Theslopeofsewer shallbe[A]
(A) Giveninthedirectionofnaturalslopeofground
(B) Giveninthedirectionoppositetonaturalslopeofground
(C) Zero
(D) Steeperthan 1in20
13. The correct relation between theoretical oxygen demand (TOD), Biochemical oxygen demand (BOD) and Chemicaloxygendemand(COD)isgivenby[B]
(A) TOD>BOD>COD
(B) TOD>COD>BOD
(C) BOD>COD>TOD
(D) COD>BOD>TOD
14. Theworkingconditionsinimhofftanksare[D]
(A) Aerobiconly
(B) Anaerobiconly
(C) Aerobicinlowercompartmentandanaerobicinuppercompartment
(D) Anaerobicinlowercompartmentandaerobicinuppercompartment
15. Thepipewhichisusedtocarrythedischargefromsanitaryfittingslikebathrooms,kitchensetc.iscalled[A]
(A) Wastepipe
(B) Soilpipe
(C) Ventpipe
(D) Anti-siphonagepipe
16. Ifthetotalhardnessofwaterisgreaterthan itstotalalkalinity,thecarbonatehardnesswill beequalto[A]

(A) Totalalkalinity
(B) Totalhardness
(C) Totalhardnesstotalalkalinity
(D) Noncarbonatehardness
17. Foragivendischarge,theefficiencyofsedimentationtankcanbeincreasedby[C]
(A) Increasingthedepthof tank
(B) Decreasingthedepthoftank
(C) Increasingthesurfaceareaof tank
(D) Decreasingthesurfaceareaoftank
18. Airbindingphenomenainrapidsandfiltersoccurdueto[A]
(A) Excessivenegativehead
(B) Mudballformation
(C) Higherturbidityintheeffluent
(D) Lowtemperature
19. Thesuitablemethodfordisinfectionofswimmingpoolwateris[A]
(A) Ultravioletraystreatment
(B) Limetreatment
(C) Byusingpotassiumpermanganate
(D) Chlorination
20. The commonly used material for water supply pipes, which has the properties of being strong, not easily corrodedandlonglifebutisheavyandbrittle,is.[B]
(A) Steel
(B) Castiron
(C) Copper
(D) Reinforcedcementconcrete

UNIT-II
PumpingofWasteWater

21. Thewatercarriagesystemofcollectionofwasteproduct.[B]
(A) Ischeaperininitialcostthandryconservancysystem
(B) Requirestreatmentbeforedisposal
(C) Createshygienicproblem
(D) Alloftheabove
22. Theeffect ofincreasingdiameterofseweronttheselfcleansingvelocityis[B]
(A) Todecreaseit
(B) Toincreaseit
(C) Fluctuating
(D) Nil
23. TherateofBOD exertedatanytimeis.[B]
(A) DirectlyproportionaltoBODsatisfied
(B) DirectlyproportionaltoBODremaining
(C) InverselyproportionaltoBODsatisfied
(D) InverselyproportionaltoBODremaining
24. Generallythedetentionperiodforgritchambersiskeptas.[A]
(A) 1minute
(B) 5minutes
(C) 24hours
(D) 12hours
25. Sludgevolumeindexisdefinedastheratioof[A]
(A) Percentageofsludgebyvolumetopercentageofsuspendedsolidsbyweight
(B) Percentageofsludgebyvolumetopercentageoftotalsolidsbyweight
(C) Percentageofsuspendedsolidsbyweighttopercentageofsludgebyvolume

(D) Percentageoftotalsolidsbyweighttopercentageofsludgebyvolume
26. Thebiochemicaltreatmentofsewageeffluentsisessentiallyaprocessof. [A]
(A) Oxidation
(B) Dehydration
(C) Reduction
(D) Alkalinization
27. Whichofthefollowingcausesadecreaseinpercapitaconsumption?[A]
(A) Useofmeteringsystem
(B) Goodqualityofwater
(C) Betterstandardoflivingofthepeople
(D) Hotterclimate
28. Thesuitablemethodofforecastingpopulationforayoungandrapidlyincreasingcityis.[B]
(A) Arithmeticalincreasemethod
(B) Geometricalincreasemethod
(C) Incrementalincreasemethod
(D) Graphicalmethod
29. Whichofthefollowingisnotawaterbornedisease? [D]
(A) Dysentery
(B) Cholera
(C) Typhoid
(D) Malaria
30. StandardEDTA(ethylenediaminetetraaceticacid)solutionisusedto determinethe. [A]
(A) Hardnessinwater
(B) Turbidityinwater
(C) Dissolvedoxygeninwater
(D) Residualchlorineinwater
31. Thesettlingvelocityofaparticleinasedimentationtankdependson. [B]
(A) Depthoftank
(B) Surfaceareaoftank
(C) Bothdepthandsurfaceareaof tank
(D) Noneoftheabove
32. Thedetention periodincoagulationtanksisusuallykeptas. [C]
(A) 1to2minutes
(B) 30to 45 minutes
(C) 2to6hours
(D) 2to6days
33. Periodofcleaningofslowsandfiltersisabout [C]
(B) 10-12days
(C) 2-3months
(D) 1-2years
34. Theprocessinwhichthechlorinationisdonebeyondthebreakpoint isknownas. [C]
(A) Pre-chlorination
(B) Postchlorination
(C) Superchlorination
(D) Breakpointchlorination
35. Disinfectionefficiencyis. [A]
(A) ReducedathigherpHvalueofwater
(B) UnaffectedbypHvalueofwater
(C) IncreasedathigherpHvalueofwater
(D) HighestatpH valueequal to7
36. Thesuitablelayoutofadistributionsystemforirregularlygrowingtownis.[A]
(B) Gridironsystem

(C) Radialsystem
(D) Ringsystem
37. Asewerthatreceivesthedischargeofanumberofhousesewersiscalled. [B]
(A) Housesewer
(B) Lateralsewer
(C) Interceptingsewer
(D) Sub-mainsewer
38. Thetimeofconcentrationisdefinedas.[C]
(A) Thetimetakenbyrainfall watertorunfrommostdistantpointofwatershedtotheinletofsewer
(B) Thetimerequiredforflowofwaterinsewerto thepointunderconsideration
(C) Sumof(A)and(B)
(D) Differenceof(A)and(B)
39. Mostsuitablesection ofsewerinseparatesewagesystemis.[B]
(A) Rectangularsection
(B) Circularsection
(C) Standardformofeggshapedsewer
(D) Modifiedeggshapedsection
40. Thepathogenscanbekilledby.[B]
(A) Nitrification
(B) Chlorination
(C) Oxidation
(D) Noneoftheabove

<u>UNIT-III</u>
SewageCharacteristics

41. Theminimumdissolvedoxygenwhichshouldalwaysbepresentinwaterinordertosavetheaquaticlifeis[B]
(A) 1ppm
(B) 4ppm
(C) 10ppm
(D) 40ppm
42. Ifthesewagecontainsgreaseandfattyoils,theseareremovedin [C]
(A) Gritchambers
(B) Detritustanks
(C) Skimmingtanks
(D) Sedimentationtanks
43. Compostingandlagooningarethemethodsof. [B]
(A) Sludgedigestion
(B) Sludgedisposal
(C) Sedimentation
(D) Filtration
44. Thegasfromsludgedigestiontankismainlycomposedof.[D]
(A) Nitrogen
(B) Carbondioxide
(C) Hydrogensulphide
(D) Methane
45. Assertion A: The consumption of water increases with increase in the distribution pressure. [A]ReasonR:Higherdistributionpressurecausesmorelossandwasteofwater
Selectyouransweraccordingtothecodingsystemgivenbelow
(A) BothAandRistrueandRisthecorrectexplanationofA
(B) BothAandRistruebut RisnotthecorrectexplanationofA

(C) AistruebutRisfalse
(D) AisfalsebutRistrue
46. Thedepressionofwatertableinawell duetopumpingwill bemaximum.[B]
(A) AtadistanceRfromthewell
(B) Closetothewell
(C) AtadistanceR/2fromthewell
(D) Noneoftheabove
Where'R'istheradiusofinfluence
47. Groundwaterisusuallyfreefrom.[A]
(A) Suspendedimpurities
(B) Dissolvedimpurities
(C) Bothsuspendedanddissolvedimpurities
(D) Noneoftheabove
48. Onstandardsilicascale,theturbidityindrinkingwatershouldbelimitedto. [A]
(A) 10ppm
(B) 20ppm
(C) 30ppm
(D) 50ppm
49. Thesettlingvelocityofaparticleinasedimentationtankincreasesif.[D]
(A) Particlesizeisdecreased
(B) Thesurfaceareaoftankisincreased
(C) Thedepthoftankisdecreased
(D) Noneoftheabove
50. Ascomparedtorapidsandfilters,slowsandfiltersgive.[C]
(i) Slowerfiltrationrate
(ii) Higherfiltrationrate
(iii) Lesserefficiencyinremovalofbacteria
(iv) Higherefficiencyinremovalofbacteria
(A) (i)and(ii)
(B) (ii)and(iii)
(C) (i)and(iv)
(D) (ii)and(iv)
51. Chlorinedemandofwaterisequalto. [D]
(A) Appliedchlorine
(B) Residualchlorine
(C) Sumofappliedandresidualchlorine
(D) Differenceofappliedandresidualchlorine
52. Inlime-sodaprocess. [C]
(A) Onlycarbonatehardnessisremoved
(B) Onlynoncarbonated hardnessisremoved
(C) Limereducesthecarbonatehardnessandsoda-ashremovesthenon-carbonatehardness
(D) Limereducesthenon-carbonatehardnessandsoda-ashremovesthecarbonatehardness
53. Whichofthefollowingmethodsofanalysisofwaterdistributionsystemismostsuitableforlongandnarrowpipesystem? [B]
(A) Circlemethod
(B) Equivalentpipemethod
(C) Hardycrossmethod
(D) Electricalanalysismethod
54. Whichofthefollowingsewersispreferredforcombinedsystemofsewage? [B]
(A) Circularsewer
(B) Eggshapedsewer
(C) Rectangularsewer

(D) Noneoftheabove
55. Aneggshapedsectionofsewer.[B]
(A) Iseconomicalthancircularsection
(B) Providesselfcleansingvelocityatlowdischarges
(C) Ismorestablethancircularsection
(D) Iseasytoconstruct
56. Sewagetreatmentunits arenormallydesignedfor. [B]
(A) 5-10years
(B) 15-20years
(C) 30-40years
(D) 40-50years
57. Themeansofaccessforinspectionandcleaningofsewerlineisknownas. [B]
(A) Inlet
(B) Manhole
(C) Dropmanhole
(D) Catchbasin
58. ThemaximumefficiencyofBODremovalisachievedin.[B]
(A) Oxidationpond
(B) Oxidationditch
(C) Aeratedlagoons
(D) Tricklingfilters
59. For the same solid content, if the quantity of sludge with moisture content of 98% is X, then the quantity of sludgewithmoisturecontentof96%willbe. [B]
(A) X/4
(B) X/2
(C) X
(D) 2X
60.Theprocessof lagooningisprimarilyameansof. [B]
(A) Reducingtheexcessiveflowinsewers
(B) Disposingofsludge
(C) Increasingthecapacityof storagereservoirs
(D) Increasingflowofsewagethroughimhofftanks

UNIT-IV
SecondaryTreatment

61. Thepercapitalconsumptionof alocalityisaffectedby. [D]
(i) Climaticconditions
(ii) Qualityofwater
(iii) Distributionpressure

(A) Only(i)
(B) Both(i)and(ii)
(C) Both(i)and(iii)
(D) All(i),(ii)and(iii)
62. Selectthecorrectrelationshipbetweenporosity(N),specificyield(y)andspecificretention (R).[A]
(A) N=y+R
(B) y=N+R
(C) R=N+y
(D) R>(N+y)
63. Themaximumpermissiblelimitforfluorideindrinkingwateris.[B]

(A) 0.1mg/liter
(B) 1.5mg/liter
(C) 5mg/liter
(D) 10mg/liter
64. Thedissolvedoxygenlevel innaturalunpollutedwatersatnormaltemperatureisfoundtobeoftheorderof.[B
]
(A) 1mg/liter
(B) 10mg/liter
(C) 100mg/liter
(D) 1000 mg/liter
65. Theamount ofcoagulantneededforcoagulationofwaterincreaseswith. [B]
(i) Increaseinturbidityofwater
(ii) Decreaseinturbidityofwater
(iii) Increaseintemperatureofwater
(iv) Decreaseintemperatureofwater
(A) (i)and(ii)
(B) (i)and(iv)
(C) (ii)and(iii)
(D) (ii)and(iv)
66. TherateofAlterationofpressurefiltersis. [C]
(A) Lessthanthatofslowsandfilters
(B) Inbetweenthefiltrationrateofslowsandfiltersandrapidsandfilters
(C) Greaterthanthat ofrapidsandfilters
(D) Equalto thatofslowsandfilters
67. Thetreatment ofwaterwithbleachingpowderisknownas. [D]
(A) Pre-chlorination
(B) Superchlorination
(C) De-chlorination
(D) Hypo-chlorination
68. Activatedcarbonisusedfor.[C]
(A) Disinfection
(B) Removinghardness
(C) Removingodours
(D) Removingcorrosiveness
69. A pipe conveying sewage from plumbing system of a single building to common sewer or point of immediatedisposaliscalled. [A]
(A) Housesewer
(B) Lateralsewer
(C) Mainsewer
(D) Sub-mainsewer
70. TheselfcleansingvelocityforallsewersinIndiaisusually. [B]
(A) Lessthan1.0m/sec
(B) 1.0m/secto1.2m/sec
(C) 1.5m/secto2.0m/sec
(D) 3.0m/secto3.5m/sec
71. Thetypeofsewerwhichissuitableforbothcombinedandseparatesystemis. [B]
(A) Circularsewer
(B) Eggshapedsewer
(C) Horseshoetypesewer
(D) Semi-ellipticalsewer

72. In a BOD test, 1.0 ml of raw sewage was diluted to 100 ml and the dissolved oxygen concentration of dilutedsample at the beginning was 6 ppm and it was 4 ppm at the end of 5 day incubation at 20°C. The BOD of raw sewagewill be. [B]
(A) 100ppm
(B) 200ppm
(C) 300ppm
(D) 400ppm
73. Corrosioninconcretesewersiscausedby [A]
(A) Septicconditions
(B) Dissolvedoxygen
(C) Chlorine
(D) Nitrogen
74. Themaindisadvantageofoxidationpondisthat. [A]
(A) Largeareaisrequiredforconstruction
(B) Maintenanceandoperation costarehigh
(C) BODremoval isverylow
(D) Noneoftheabove
75. Mostofthebacteriainsewageare.[B]
(A) Parasitic
(B) Saprophytic
(C) Pathogenic
(D) Anaerobic
76. Thehourlyvariationfactorisusuallytakenas.[A]
(A)1.5
(B)1.8
(C)2.0
(D)2.7
77. Themaximumdischargeofatubewell isabout.[B]
(A) 5liters/sec
(B) 50liters/sec
(C) 500liters/sec
(D) 1000liters/sec
78. Turbidityismeasuredon. [A]
(A) Standardsilicascale
(B) Standardcobaltscale
(C) Standardplatinumscale
(D) Platinumcobaltscale
79. Theoverflowrateforplainsedimentationtanksisabout[A]
(A) 500to 750 liters/hour/m^2
(B) 1000 to1250liters/hour/m^2
(C) 1250to 1500liters/hour/m^2
(D) 1500to2000liters/hour/m^2
80. Assertion A: Slow sand filters are more efficient in removal of bacteria than rapid sand filters.ReasonR:Thesandusedinslowsandfiltersisfinerthanthatinrapidsandfilters
Selectyouranswerbasedonthecodingsystemgivenbelow:. [A]
(A) BothAandRistrueandRisthecorrectexplanationofA
(B) BothAandRistruebutRisnotthecorrectexplanationofA
(C) AistruebutRisfalse(D)AisfalsebutRistrue

UNIT-V

MiscellaneousTreatmentMethods

81. Whichofthefollowingchemicalcompoundscanbeusedforde-chlorinationofwater?[C]
(A) Carbondioxide

(B) Bleachingpowder
(C) Sulphurdioxide
(D) Chloramines
82. Hardycrossmethodofanalysisofdistributionsystem. [C]
(i) Involvessuccessivetrials
(ii) Takeseconomicaspectsinto account
(iii) Istimeconsuming
(A) Only(i)
(B) (i)and(ii)
(C) (i)and(iii)
(D) Allarecorrect
83. AveragerateofwaterconsumptionperheadperdayasperIndianStandardis. [B]
(A) 100liters
(B) 135liters
(C) 165liters
(D) 200liters
84. Thehydraulicmeandepth(HMD)foranegg-shapedsewerflowingtwo-thirdfull is. [C]
(A) EqualtoHMDwhenflowingfull
(B) LessthanHMDwhenflowingfull
(C) GreaterthanHMDwhenflowing full
(D) Noneoftheabove
85. Selectthecorrectstatement. [C]
(A) 5dayBODistheultimateBOD
(B) 5dayBODisgreaterthan4 dayBOD keepingotherconditionssame
(C) 5dayBODislessthan4 dayBODkeepingotherconditionssame
(D) BODdoesnot dependontime
86. Layingofsewersisusuallydonewiththehelpof. [C]
(A) ATheodolite
(B) Acompass
(C) Sightrailsandboningrods
(D) Aplanetable
87. Fornormalsludge,thevalueofsludgeindexforIndianconditionsis.[C]
(B) 50 to
150(C) 150 to
350(D)350to50
0
88. Iftheaveragedailyconsumptionofacityis100,000m3,themaximumdailyconsumptiononpeakhourlydemandwill be.[D]
(A)100000m3
(B)150000m3
(C)180000m3
(D)270000m3
89. Themostcommoncauseofacidityinwateris.[A]
(A) Carbondioxide
(B) Oxygen
(C) Hydrogen
(D) Nitrogen
90. Theamount ofresidualchlorineleftinpublicwatersupplyforsafetyagainstpathogenicbacteriaisabout. [B]
(A)0.01to0.05ppm
(B) 0.05to 0.5ppm
(C) 0.5to1.0ppm
(D) 1.0to 5.0ppm

91. The detention period and overflow rate respectively for plain sedimentation as compared to sedimentation withcoagulationaregenerally. [C]
(A) Lessandmore
(B) Lessandless
(C) Moreandless
(D) Moreandmore
92. Theeffectivesizeofsandparticlesusedinslowsandfiltersis.[A](A)0.25to
0.35mm
(B)0.35to 0.60mm
(C)0.60to1.00 mm
(D)1.00to 1.80mm
93. Inchlorination,withtheriseintemperatureofwater,deathrateofbacteria. [A]
(A) Increases
(B) Decreases
(C) Remainsunaffected
(D) Noneoftheabove
94. The method of analysis of distribution system in which the domestic supply is neglected and fire demand isconsideredis. [A]
(A) Circlemethod
(B) Equivalentpipemethod
(C) Electricalanalysismethod
(D) Hardycrossmethod
95. Thespecificgravityofsewageis. [D]
(A) Muchgreaterthan 1
(B) Slightlylessthan1
(C) Equalto1
(D) Slightlygreaterthan1
96. Whichofthefollowingretardstheselfpurificationofstream? [D]
(A) Highertemperature
(B) Sunlight
(C) Satisfyingoxygendemand
(D) Noneoftheabove
97. Seweragesystemisdesignedfor. [D]
(A) Maximumflowonly
(B) Minimumflowonly
(C) Averageflowonly
(D) Maximumandminimumflow
98. Infacultativestabilizationpond,thesewageistreatedby. [C]
(A) Aerobicbacteriaonly
(B) Algaeonly
(C) Dualactionofaerobicbacteriaandanaerobicbacteria
(D) Sedimentation
99. Apipewhichisinstalledinthehousedrainagetopreservethewaterseal oftrapsiscalled[B]
(A) Ventpipe
(B) Anti-siphonagepipe
(C) Wastepipe
(D) Soilpipe

100. Thedistributionmainsaredesignedfor.[D]
(A) Maximumdailydemand
(B) Maximumhourlydemand

(C) Averagedailydemand
(D) Maximumhourlydemandonmaximumday.
101. Thetypeofvalve,whichisprovidedonthesuctionpipeinatube-well,is.[B]
(A) Airreliefvalve
(B) Refluxvalve
(C) Pressurereliefvalve
(D) Sluicevalve
102. Alkalinityinwaterisexpressedasmilligramsperlitreintermsofequivalent.[A]
(B) Magnesiumcarbonate
(C) Sodiumcarbonate
(D) Calciumhydroxide
103. Thelengthofrectangularsedimentationtankshouldnot bemorethan.[C]
(A) B
(B) 2B
(C) 4B
(D) 8B
Where‘B’isthewidthofthetank
104. Inwatertreatment, rapidgravityfiltersareadoptedtoremove.[D]
(A) Dissolvedorganicsubstances
(B) Dissolvedsolidsanddissolvedgases
(C) Floatingsolidsanddissolvedinorganicsolids
(D) Bacteriaandcolloidalsolids
105. Disinfectionofwaterresultsin. [C]
(A) Removalofturbidity
(B) Removalofhardness
(C) Killingofdiseasebacteria
(D) Completesterilisation
106. The type of valve which is provided to control the flow of water in the distribution system at street corners andwherethepipelinesintersectis[B]
(A) Checkvalve
(B) Sluicevalve
(C) Safetyvalve
(D) Scourvalve
107. Thedesigndischargefortheseparatesewersystemshall betakenas.[D]
(A) Equaltodryweatherflow(DWF)
(B) 2×DWF
(C) 3×DWF
(D) 6×DWF
108. Themostcommonlyusedsewerunderculvertsis.[A]
(A) Circularbricksewer
(B) Circularcastironsewer
(C) Semi-ellipticalsewer
(D) Horseshoetypesewer
109. The relative stability of a sewage sample, whose dissolved oxygen is same as the total oxygen required to satisfyBOD,is.[B]
(A)1
(B)100
(C) Infinite
(D) Zero
110. Forsatisfactoryworkingofasludgedigestionunit,thepHrangeofdigestedsludgeshouldbemaintainedas.[B
]
(A)4.5to6.0

(B)6.5to8.0
(C)8.5to10.0
(D)10.5to12.0
111. Ascomparedto geometricalincreasemethodofforecastingpopulation,arithmeticalincreasemethodgives.[A]
(A) Lesservalue
(B) Highervalue
(C) Samevalue
(D) Accuratevalue
112. Thephenolic compoundsinpublicwatersupplyshouldnotbemorethan.[C]
(A) 0.1ppm
(B) 0.01ppm
(C) 0.001ppm
(D)0.0001ppm
113. Percentageofbacterialloadthatcanberemovedfromwaterbytheprocessofplainsedimentationisabout.[C]
(A) 10to25
(B) 50
(C) 75
(D)100
114. Doublefiltrationisused. [A]
(A) Toincreasethefiltrationslowsandfilterscapacityof
(B) Toincreasethefiltrationrapidsandfilterscapacityof
(C) Forisolatedbuildingslikepools,hotelsetcswimming
(D) Alloftheabove
115. Themajordisadvantageoflimesodaprocessofwatersofteningisthat.[B]
(A) Itisunsuitableforturbidandacidicwater
(B) Hugeamountofprecipitateisformedwhichcreatesadisposalproblem
(C) Theeffluentcannotbereducedtozero hardness
(D) Itisunsuitableforsofteningthewaterofexcessivehardness
116. Scourvalvesareprovided. [B]
(A) Atstreetcornerstocontroltheflowofwater
(B) Ateverydepressionanddeadendstodrainoutthewastewaterthat maycollectthere
(C) Atthefoot ofrisingmainalongtheslopetopreventbackrunningofwater
(D) Ateverysummitofrisingmains
117. Thevelocityofflowdoesnotdepend on.[B]
(A) Gradeofsewer
(B) Lengthofsewer
(C) Hydraulicmeandepthofsewer
(D) Roughnessofsewer
118. Theratio of5 dayBOD to ultimateBODisabout.[B]
(A)1/3
(B)2/3
(C)3/4
(D)1.0
119. Septictankisa. [B]
(i) Settlingtank
(ii) Digestiontank
(iii) Aerationtank
(A) Only(i)
(B) (i)and(ii)
(C) (i)and(iii)

(D) Only(iii)

120. The population of a town in three consecutive years are 5000, 7000 and 8400 respectively. The population of thetowninthefourthconsecutiveyearaccordingtogeometricalincreasemethodis. [D]

(A)9500

(B)9800

(C)10100

(D)10920

121. Whichofthefollowingcompoundsiswidelyusedforalgaecontrol? [B]

(A) Sodiumsulphate

(B) Coppersulphate

(C) Sodiumchloride

(D) Calciumchloride

122. Dissolvedoxygeninstreamsis. [A]

(A) Maximumatnoon

(B) Minimumatnoon

(C) Maximumatmidnight

(D) Samethroughouttheday

123. Ifthecoli formbacteriaispresentinasampleofwater,thenthecoli-formtest tobeconductedis. [D]

(i) Presumptivecoli-formtest

(ii) Confirmedcoli-formtest

(iii) Completedcoli-formtest

(A) Only(i)

(B) Both(i)and(ii)

(C) Both(i)and(iii)

(D) All(i),(ii)and(iii)

124. AscomparedtohigherpHvalues,thecontactperiodrequiredforefficientchlorinationatlowerpHvalues is. [A]

(A) Smaller

(B) Larger

(C) Same

(D) Noneoftheabove

125. StandardBODismeasuredat. [C]

(A) 20°C -1day

(B) 25°C -3day

(C) 20°C -5day

(D) 30°C -5day

126. Thevelocityofflowofwaterinasedimentationtankisabout.[C]

(B) 15to30 cm/sec

(C) 15to 30cm/minute

(D) 15to30cm/hour

127. Alumasacoagulantisfoundtobemost effectivewhenpHrangeofwateris. [C]

(A) 2to4

(B) 4to6

(C) 6to8

(D) 8to 10

128. Thepercentageoffilteredwater,whichisusedforbackwashinginrapidsandfilters,isabout. [C
](A)0.2to0.4

(B)0.4to1.0

(C) 2to4

(D) 5to7

129. ForacountrylikeIndia,whererainfallismainlyconfinedtooneseason,thesuitableseweragesystemwill be. [A]

(A) Separatesystem
(B) Combinedsystem
(C) Partiallycombinedsystem
(D) Partiallyseparatesystem
130. If the time of concentration is 9 minutes, then the intensity of rainfall according to British Ministry of Healthformulawill be. [D]
(A) 4mm/hr
(B) 10mm/hr
(C) 20mm/hr
(D) 40mm/hr
131. The minimum and maximum diameters of sewers shall preferably be.[B]
(B) 15cmand300cm
(C) 30cmand450cm
(D) 60cmand300cm
132. Sewagetreatmentunitsaredesignedfor. [C]
(A) Maximumflowonly
(B) Minimumflowonly
(C) Averageflowonly
(D) Maximumandminimumflow
133. Whenthereisnorecirculationofsewage,thenrecirculationfactoris.[B]
(B) 1
(C) Infinity
(D) Noneoftheabove
134. WhichofthefollowingvaluesofpHrepresentsastrongeracid? [A]
(A) 2
(B) 5
(C) 7
(D) 10
135. Thealum,whenaddedasacoagulantinwater. [D]
(A) Doesnotrequirealkalinityinwaterforflocculation
(B) DoesnotaffectpHvalueofwater
(C) IncreasespHvalueofwater
(D) DecreasespHvalueofwater
136. Cleaningisdoneby. [C]
(i) Scrapingandremovalinfiltersslowsand
(ii) Backwashinginslowsandfilters
(iii) Scrapingandremovalinfiltersrapidsand
(iv) Backwashinginrapidsandfilters
(A) (i)and(ii)
(B) (ii)and(iii)
(C) (i)and(iv)
(D) (ii)and(iv)
137. Ascomparedtocastironpipes,steelpipesare. [B]
(A) Heavier
(B) Stronger
(C) Costlier
(D) Lesssusceptibletocorrosion
138. Thedesigndischargeforthecombinedsewersystemshallbetakenas. [C]
(A) Equaltorainfall
(B) Rainfall+DWF
(C) Rainfall+2DWF

(D) Rainfall +6DWF
139. If Biochemical oxygen demand (BOD) of a town is 20000 kg/day and BOD per capita per day is 0.05 kg, thenpopulationequivalentoftownis. [D]
(A)1000
(B)4000
(C)1,00,000
(D)4,00,000
140. Thedetentionperiodforoxidationpondsisusuallykeptas. [C]
(A) 48hours
(B) 24hours
(C) 10to 15days
(D) 3months
141. Thedeviceswhichareinstalledfordrawingwaterfromthesourcesarecalled. [D]
(A) Aquifers
(B) Aquiclude
(C) Filters
(D) Intakes
142. Residualchlorineinwaterisdeterminedby. [C]
(A) Starchiodidemethod
(B) Orthotolidinemethod
(C) Both(A)and(B)
(D) Noneoftheabove
143. Thepercentageofchlorineinfreshbleachingpowderisabout. [C]
(B) 20to25
(C) 30to35
(D) 40to50
144. Seweragesystemisusuallydesignedfor. [B]
(A) 10years
(B) 25years
(C) 50years
(D) 75years
145. Thecharacteristicsoffreshandsepticsewagerespectivelyare. [B]
(A) Acidicandalkaline
(B) Alkalineandacidic
(C) Bothacidic
(D) Bothalkaline
146. Whichofthefollowingunitworksinanaerobicconditions? [A]
(A) Sludgedigestiontank
(B) Sedimentationtank
(C) Activatedsludgetreatment
(D) Tricklingfilters
147. Ascomparedto shallowwells,deepwellshave. [C]
(A) Moredepth
(B) Lessdepth
(C) Moredischarge
(D) Lessdischarge

148. Therateoffiltrationinslowsandfiltersinmillionlitresperdayperhectareisabout. [A]
(A) 50 to
60(B) 100 to
150(C)500to6
00

(D)1400to1500

12. QuestionBank(DescriptiveQuestionswithBLOOMSTaxonomy)

DADIINSTITUTEOFENGINEERINGANDTECHNOLOGY

(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)

NAACAccreditedInstitute

An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified InstituteNH–16, Anakapalle, Visakhapatnam–531002, Andhra Pradesh**DEPARTMENTOFCIVILENGINEERING**

PROGRAM **:** B.Tech

CE**CLASSANDSEMESTER** **:**IV B.Tech., I-Sem.,

CE**ACADEMICYEAR** **:**2019-20

COURSENAME&CODE: EnvironmentalEngineering-II

COURSEINSTRUCTOR **:** Mr.B.Seshgiri Rao

UNIT-I

CO	Level	Q.No	Questions
1	3	1	Design a sewer for a maximum discharge of 650 L/s running half full.Consider manning's rugosity coefficient n=0.012, and gradient of sewer =0.0001
1	2	2	Explain indetailthe variousstepsinvolvedindesignofsewers.
1	1	3	Definehealthandsanitation. Mentionvariouscomponentsofsanitationanddefine1.Sewage 2.Sullage3.Sewerage 4.Sewer5.DWF6.WWF.
1	1	4	Discussthevariousmethodsforestimatingsewageflowandstormwaterflow.
1	2	5	Mentionthesanitary fittingsusedinplumbing andexplain.

UNIT-II

CO	Level	Q.No	Questions
2	2	1	Explaintypesofpumpsandtheirsuitabilitywithregardtowastewaters.
2	2	2	Explainonepipeand twopipesystems.
2	2	3	ExplainDesignofbuilding drainage.
2	1	4	WhatisaPump?Classifythepumpsbasedonmechanicalprinciplesindicatingmerits anddemerits ofeachtypeofpump.
2	2	5	Writeaboutdifferenttypesofpumpsandfactorstobeconsideredinselectionofpumpsforsewerage.

UNIT-III

CO	Level	Q.No	Questions
3	2	1	ExplainPhysical,ChemicalandBiologicalExaminationandSamplingandanalysis ofwastewater.
3	3	2	DrawtheSewageTreatmentProcessandexplain.
3	3	3	A 2% dilution of sewage sample is incubated for 5 days at 20°C. Thedepletion of oxygen wasfoundtobe4ppm.DeterminetheBOD$_5$ofsewageat 20°C.CalculateultimateBODand2dayBODat 35^{oC}and Estimate BOD$_5$@20°C whose BOD$_8$@ 20°C is given as 160mg/L. AssumeBOD rateconstantke=0.225d^{-1}.
3	3	4	DefineBODandCOD.DeriveamathematicalexpressionforfirstorderBOD.Also discussfirststageandsecondstageBOD.
3	3	5	Design a grit Chamber to treat 10MLD of sewage. Assume surface loadingrate of 1200m3/day/m2 and HDT of 60 seconds. Mention velocity controldevices.
3	2	6	Explainthephenomenaofselfpurificationinrunningstreams.Drawtheoxygensagcurveandexplainits significance.

UNIT-IV

CO	Level	Q.No	Questions
4	2	1	Explain ActivatedSludgeProcess,principles,designs,andoperationalproblems,modificationsofActivatedSludgeProcesses
4	2	2	ExplainTricklingFiltersandmechanismofimpuritiesremoval
4	2	3	ExplainRBCs,Fluidizedbedreactors.
4	3	4	DesignahighrateTricklingFiltertotreat30MLDofsewage.Assumesuitable designdata.
4	3	5	Drawprocessflowdiagramofhighratetwostagetricklingfilteranddiscuss itsfunction.Alsoexplaintheimportanceofrecirculation.

UNIT-V

CO	Level	Q.No	Questions
5	2	1	Explain NitrificationandDenitrificationandRemovalofPhosphates–UASB
5	2	2	ExplainSepticTanksandImhofftanks-working Principles
5	3	3	DifferentiateanddiscussthefunctioningofSeptictankandImhofftank.
5	2	4	Designsinglechamberseptictanktotreatsewagefor60persons.Followprocedure asgiveninBIS2470(Codeofpracticefordesignand constructionof septictanks).Drawthesketchof

			septictankforthedesign.Assume4personsperfamily.
5	3	5	Explainsludgethickeningandanaerobicdigestionofsludgeand Explainmethods ofsewagedisposal.

CO : Course Outcomes Blooms Taxonomy Levels

L1:Remembering

L2 : Understanding

L3:Applying

L4 :Analysing

L5:Evaluating

L6:Creating

13. PreviousUniversityQuestionpapers(MinimumFive)

October 2019 R 16(SET 1)

PART–A*(14Marks)*

1. a) Whatarethefactorswhichmainlyaffectthequantityofstormsewage? [3]
b) Explaintheclassificationoftraps. [3]
c) DistinguishbetweenBODandCOD. [2]
d) WhataretheobjectivesofOxidationPond? [2]
e) WhatdoyoumeanbyNitrification? [2]
f) Definesewagesickness. [2]

PART–B*(4x14=56Marks)*

2. a) Whatdoyoumean by variationinflow ofsewage?Discussaverageflow,dryweatherflow,andmaximumflow. [7]
b) A30cmdia.sewerhaving an invertslope of 1in150was flowing full.Whatwouldbethevelocity offlowanddischarge?(n=0.013).Isthevelocityselfcleansing? Whatwouldbethevelocityandthedischargewhenthesameisflowing0.20and0.8ofthefulldepth? [7]

3. a) Briefly discusswithneatsketchthefunctionsandusesofasewagepumpingstation. [8]

4. a)Stateanddescribefourimportantteststhatmaybecarriedouttoknowthecharacteristicsofsanitarysewage. [6]
b) The average sewage flow from a city is 80 x 106l/d. If the average 5-days BODis285mg/l,computethetotaldaily5-dayoxygendemandinkg,andthepopulationequivalentofsewagek=0.1.AssumepercapitaBODofthesewage perday=75gm. [8]

5. a) Differentiatesuspendedgrowthprocessandattachedgrowthprocess. [7]

6. a) ExplainamethodforremovalofPhosphates. [7]
b) Designaseptictakeforasmallcolonyof100personswithdailysewageflowof 135 litresperheadperday. [7]

7. a) Writenotesonselfpurificationofstreams. [7]
b) Describetheultimatedisposalofwastewater.

October 2019 R 16(SET 2)

PART–A*(14Marks)*

1. a) Explainthetimeofconcentrationanditssignificanceindesignofstormsewers.
b) WriteaHazenWilliam'sformulaforofwaterthroughpipe.
c) WhatisthepurposeofFlotation?
d) WhataretheobjectivesofActivatedsludgeprocess?
e) WhatdoyoumeanbyDenitrification?
f) Whatarethedifferentmethodsofsewagedisposal?

PART–B*(4x14=56Marks)*

2. a) Drawtwosuitablesu

disadvantages.

b) Asanitaryseweristoserveauniformlydistributedpopulationof10,000alonga 1.000mroad.Theaveragegroundslopeforfirst500mis1in400,andfortheremainingas1 in900.Designthesewer.Giveexpectedpeak,averageand minimumvelocities.Makesuitableassumptions,andstatethemclearly.

3. a) Enumerate the different types of pumps usedforsewage pumping. Whatare theiradvantagesanddisadvantages?

b) Explaintwopipesystemofplumbing.

4. a) Explaintheimportanceofdeterminationofsolidsinsewage.Howdoyou determinethesuspendedsolidsinagivensampleofwaste? [7]

b) The3day37^{o}CBODofasampleofsewageis300ppm.Whatwillbeits10days–20^{o}CBODand5day30^{o}CBOD? [7]

5. a) Discusstheprocessinvolvedinatricklingfilter.

b) Explainthemethodsofaerationindetail.

6. a) DescribetheobjectivesofImhofftankintreatmentprocess?

b) Designaseptictakeforasmallcolonyof150personswithdailysewageflowoff 135litresperheadper day.

7. a) Explaintheobjectivesofsludgedrying?

b) WritenotesonSewagefarming.

<u>October 2019 R 16(SET 3)</u>

<u>PART–A</u>*(14Marks)*

1. a) Mentionthevariousaspectsyouwouldkeepinviewwhiledesigningasewer. [3]
   b) Underwhatcircumstancesmanholesareprovidedinseweragesystem.
   c) Stateteprincipleofsedimentation.
   d) WhatarethemodificationsofActivatedsludgeprocess?
   e) WhataretheobjectivesofNitrification?
   f) WhataretheobjectivesofSludgetreatment?

<u>PART–B</u>*(4x14=56Marks)*

2. a) Explainthemethodsofsewagecollection. [6]

b) A30cm diaseweran invertslope of 1in 400is flowing 1/3rd of the full depth.Calculatethevelocityandtherate offlowinthesewer. Isitself-cleaningvelocity?Usen=0.015. [8]

3. a) Discussthedifferentcomponentsofapumpingstation? [8]

b) Describethedifferentsystemsofplumbing?Explainanyoneindetail.

4. a) Enumeratevariousmethodsavailablefortreatmentofwastewater. [6]

b) The effluent from a primary settling tank is applied to a standard rate filter at therate of 4 million liters per day, having a BODs of 175 mg/l.Determine the depthand volume of filter, adopting a surface loading of 2000 l/m^2/day and an organicloadingof150g/m^3/day.Also,determinetheefficiencyofsuchfilterunit,using NRCformula.

5. a) Describestandardandhighratetricklingfiltersandcomparison. [8]

b) ExplainGritchamberwithaneatsketchanddesignspecification.

6. a) Writenotesonreuseandrecycleofseptictankeffluent. [6]

b) Designaseptictakeforasmallcolonyof200personswithdailysewageflowof 135litresperheadperday.

7. a) Writedetailednotesontreatmentofsludge. [7]

b) Explainthedisposalofsewageintosea.

October 2019 R 16(SET 4)

PART–A*(14Marks)*

1. a) Howdoesthevariationofsewageflowaffectitsvelocityinacircularsewer? [3]

b) Mentionwhichtypeofpumpismostsuitableforsewagepumping.Givereasons.

c) Whataretheobjectivesofgritremoval?

d) Distinguishbetweenunitoperationsandunitprocesses.

e) WhataretheobjectivesofDenitrification?

f) DifferentiateAerobicdigestionandanaerobicdigestion.

PART–B*(4x14=56Marks)*

2.a) Whatarethedifferenthydraulicelementsandtherelationthatexistsbetweenthem,whichgoverntheдischargethroughasewer? [6]

b) Designasanitarysewerwiththefollowingdata:

(i) Populationserved = 25,000

(ii) Expectedsewageflow = 135l/c/d(average)

(iii) Averageslopeoftheground = 1in500 [8]

1. a) Describetheprocedureforlayingandtestingofsewers. [6]

b) Whatarethe functions of a manhole.Describe with thehelpof neatsketches theComponentsofamanhole. [8]

2. a) Drawthelayoutandgenera

b) Define“biologicaltreatmentofsewage”?Explaintheprincipleofbiologicaltreatment? [6]

3. a) Distinguishbetweenstandardrateandhighratetricklingfilter. [7]

b) Explaintheprimarytreatmentprocessesinwastewater.

4. a) ExplainDenitrificationprocess. [6]

b) Designaseptictakeforasmallcolonyof250personswithdailysewageflowof 135litresperheadperday.

5. a) Explainsludgedigestion?Whatarethefactorsaffectingit? [7]

b) WriteshortnotesonSludgedisposal.

14. GATEQuestions(Unitwise)

15. CampusPlacement/InterviewQuestions(Unitwise)

16A.Internal(Mid)ExaminationsQuestionPapers

16B.FirstMidInternalMarksofrespectiveSubject,MidMarksAnalysisandActionTakenReport

		EE-I			
S.NO	ROLL NO	M(10)	Q(10)	A(5)	T(25)
1	16U41A0101				
2	16U41A0102				
3	16U41A0104				
4	16U41A0106				
5	16U41A0107				
6	16U41A0108				
7	16U41A0109				
8	16U41A0110				
9	16U41A0111				
10	16U41A0112				
11	16U41A0113				
12	16U41A0114				
13	16U41A0115				
14	16U41A0116				

15	17U45A0101				
16	17U45A0102				
17	17U45A0103				
18	17U45A0104				
19	17U45A0105				
20	17U45A0106				
21	17U45A0107				
22	17U45A0108				
23	17U45A0109				
24	17U45A0110				
25	17U45A0111				
26	17U45A0112				
27	17U45A0113				
28	17U45A0114				
29	17U45A0115				
30	17U45A0116				
31	17U45A0117				
32	17U45A0118				
33	17U45A0119				
34	17U45A0120				
35	17U45A0121				
36	17U45A0122				
37	17U45A0123				
38	17U45A0124				

39	17U45A0125				
40	17U45A0126				
41	17U45A0127				
42	17U45A0128				
43	17U45A0129				
44	17U45A0130				
45	17U45A0131				
46	17U45A0132				
47	17U45A0133				
48	17U45A0134				
49	17U45A0135				
50	17U45A0136				
51	17U45A0137				
52	17U45A0138				
53	17U45A0139				
54	17U45A0140				
55	17U45A0141				
56	17U45A0142				
57	17U45A0143				
58	17U45A0144				
59	17U45A0145				
60	17U45A0146				
61	17U45A0147				
62	17U45A0148				

63	17U45A0149				
64	17U45A0151				

DADIINSTITUTEOFENGINEERINGANDTECHNOLOGY

(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)

NAACAccreditedInstitute

An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified InstituteNH–16,Anakapalle, Visakhapatnam–531002,AndhraPradesh

DEPARTMENTOFCIVILENGINEERINGE NVIRONMENTAL ENGINEERING-IIMidIANALYSISREPORT

PROGRAM :B.Tech

CLASS :IIIB.TechI-Sem., CE

ACADEMICYEAR :2021-2022

COURSENAME&CODE: EnvironmentalEngineering

COURSEINSTRUCTOR :Mrs.K.Manoharini

DateofMidExam :

S.No.	%ofInternalMarks	Regd.NosofStudents	No.ofStudents	Suggestions andActionTaken
1	>=75%	18U45A010818U45A011818U45A012118U45A0126 18U45A012718U45A012818U45A013818U45A0139 18U45A014118U45A014418U45A0149	11	Students are suggested todraw the figures and thenexplain the theory relatedtoit
2	>=50%and <75%	16U41A010517U41A010117U41A010217U41A0103 17U41A010517U41A010717U41A010917U41A0110 18U45A010118U45A010218U45A010318U45A0104 18U45A010518U45A010618U45A010718U45A0109 18U45A011018U45A011118U45A011218U45A0113 18U45A011418U45A011518U45A011618U45A0117 18U45A011918U45A012018U45A012218U45A0123 18U45A012518U45A013118U45A013318U45A0135 18U45A013618U45A013718U45A014218U45A0143 18U45A014518U45A014618U45A014718U45A0148 18U45A015018U45A0151	44	Students are suggested toPractice all the topics ofeachunit.
3	<50%	17U41A010818U45A0129	02	Mid Question Paperhas been given as aSpecialAssignment . Students have written theAssignment. Planning to conductRemedialClasses forthe students who have gotLessthan50%Marks
4	ABSENT	18U45A0132	01	----

AnyOtherRemarks:

CourseInstructor	**CourseCo-Ordinator**	**ModuleCo-Ordinator**	**ProgramCo-Ordinator**	**HOD**

16C.SecondMidInternalMarksofrespectiveSubject,MidMarksAnalysisandActionTaken Report

		EE-I			
S.NO	ROLL NO	M(10)	Q(10)	A(5)	T(25)
1	16U41A0101				
2	16U41A0102				
3	16U41A0104				
4	16U41A0106				
5	16U41A0107				
6	16U41A0108				
7	16U41A0109				
8	16U41A0110				
9	16U41A0111				
10	16U41A0112				
11	16U41A0113				
12	16U41A0114				
13	16U41A0115				
14	16U41A0116				
15	17U45A0101				
16	17U45A0102				
17	17U45A0103				
18	17U45A0104				
19	17U45A0105				
20	17U45A0106				
21	17U45A0107				

22	17U45A0108				
23	17U45A0109				
24	17U45A0110				
25	17U45A0111				
26	17U45A0112				
27	17U45A0113				
28	17U45A0114				
29	17U45A0115				
30	17U45A0116				
31	17U45A0117				
32	17U45A0118				
33	17U45A0119				
34	17U45A0120				
35	17U45A0121				
36	17U45A0122				
37	17U45A0123				
38	17U45A0124				
39	17U45A0125				
40	17U45A0126				
41	17U45A0127				
42	17U45A0128				
43	17U45A0129				
44	17U45A0130				
45	17U45A0131				

46	17U45A0132				
47	17U45A0133				
48	17U45A0134				
49	17U45A0135				
50	17U45A0136				
51	17U45A0137				
52	17U45A0138				
53	17U45A0139				
54	17U45A0140				
55	17U45A0141				
56	17U45A0142				
57	17U45A0143				
58	17U45A0144				
59	17U45A0145				
60	17U45A0146				
61	17U45A0147				
62	17U45A0148				
63	17U45A0149				
64	17U45A0151				

DADIINSTITUTEOFENGINEERINGANDTECHNOLOGY

(ApprovedbyA.I.C.T.E.,NewDelhi&PermanentlyAffiliatedtoJNTUK,Kakinada)

NAACAccreditedInstitute

An ISO 9001:2008, 14001:2004 & OHSAS 18001:2007 Certified InstituteNH–16,Anakapalle, Visakhapatnam–531002,AndhraPradesh

DEPARTMENTOFCIVILENGINEERINGE

NVIRONMENTAL ENGINEERING-
IIMidIIANALYSISREPORT

PROGRAM :B.Tech
CLASS :IV B.TechI-Sem., CE
ACADEMICYEAR :2019-20
COURSENAME&CODE: EnvironmentalEngineering
COURSEINSTRUCTOR :Mr.B.Seshagiri Rao
DateofMidExam :

S.No.	%ofInternalMarks	Regd.NosofStudents	No.ofStudents	Suggestions andActionTaken
1	>=75%	17U41A010117U41A010717U41A011018U45A0108 18U45A010118U45A010218U45A010418U45A0107 18U45A011618U45A011818U45A011918U45A0126 18U45A012718U45A012818U45A013118U45A0135 18U45A013618U45A013718U45A013918U45A0141 18U45A014418U45A014918U45A0151	23	Students are suggested todraw the figures and thenexplain the theory relatedtoit
2	>=50%and <75%	16U41A010517U41A010217U41A010317U41A0105 17U41A010917U41A0108 18U45A010518U45A010618U45A010918U45A0110 18U45A011118U45A011218U45A011318U45A0114 18U45A011518U45A011718U45A012218U45A0123 18U45A012518U45A012918U45A013318U45A0138 18U45A014318U45A014518U45A014618U45A0147 18U45A014818U45A0150	28	Students are suggested toPractice all the topics ofeachunit.
3	<50%	18U45A0120,18U45A0142	02	Suggested to concentratemoreonpreviouspapers
4	ABSENT	18U45A0103,18U45A0132,18U45A0121	03	----

AnyOtherRemarks:

CourseInstructor **CourseCo-Ordinator** **ModuleCo-Ordinator** **ProgramCo-Ordinator** **HOD**

17. Detailednotes(Unitwise):

- HandwrittenNotes(onA4Pages)shouldbepreparedforeverysubject.
- EachUnitshouldconsistofminimumTenPages.ThetotalHandwrittenNotes mustbearound50 to60Pages.
- Additionalmaterial suchasPrintoutsofPPTscanalsobeadded.

18. QualitymeasurementSheets

- Teachingevaluation(FeedbackreceivedfromIQAC)
- AcademicAuditreportreceivedfromIQAC

19. Attainment of CosandPos(asperthesuggestionofNBACo-Ordinator)
(DetailedProcedureusedtocalculatetheattainmentofCosandPOs)Note:Sep aratesheetsmustbeattached

20. ClosureReport/CourseReview(Bythe concernedFaculty):

AttheEndofthecoursethereportshouldbegivenbytheconcernedfaculty

PARTA:
No. of classes planned using Traditional Teaching Learning Methods(TLM 1):No. ofclassesplannedusingLCDProjector(TLM 2):
No.ofclassesplannedtocoverTutorials(TLM3):
No.ofclassesplannedusingModernTeachingLearningMethods(TLM4toTLM8)
No. of classes planned using TLM 4
No. of classes planned using TLM 5
No. of classes planned using TLM 6
No. of classes planned using TLM 7
No.ofclassesplannedusingTLM8
No.ofclassesplannedtocoverAdditionalTopics(ifany):
TotalNumberofclassesplanned-

PARTB:
No. of classes taught using Traditional Teaching Learning Methods(TLM 1):No. ofclasses taughtusingLCDProjector(TLM2):
No.ofclassestaughttocoverTutorials(TLM3):
No.ofclassestaught usingModernTeachingLearningMethods(TLM4toTLM8)No. of classestaughtusingTLM4
No. of classes taught using TLM 5No. of classes taught using TLM 6No. of classes taught using TLM 7No.ofclassestaughtusingTLM8
No.ofclassestaughttocoverAdditionalTopics(ifany):
TotalNumberofclassesactuallytaken–

PARTC:

Total Number of students attended for the First Mid exam –
27Total Number of students attended for the Second Mid exam-
27Total Number of students attended for the JNTU External
exam -Total numberof studentspassedtheCourse-
Passpercentageofthe Class -
Total numberofstudentspassedtheCourseinReValuation/Recounting-

CourseInstructor **CourseCoordinator** **ModuleCo-Ordinator** **ProgramCo-Ordinator** **HOD**

AcademicConvenor **DeanIQAC** **Principal**

REVISED Bloom's Taxonomy Action Verbs

Definitions	I. Remembering	II. Understanding	III. Applying	IV. Analyzing	V. Evaluating	VI. Creating
Bloom's Definition	Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.	Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.	Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria.	Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions.
Verbs	• Choose • Define • Find • How • Label • List • Match • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Classify • Compare • Contrast • Demonstrate • Explain • Extend • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate	• Apply • Build • Choose • Construct • Develop • Experiment with • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize	• Analyze • Assume • Categorize • Classify • Compare • Conclusion • Contrast • Discover • Dissect • Distinguish • Divide • Examine • Function • Inference • Inspect • List • Motive • Relationships • Simplify • Survey • Take part in • Test for • Theme	• Agree • Appraise • Assess • Award • Choose • Compare • Conclude • Criteria • Criticize • Decide • Deduct • Defend • Determine • Disprove • Estimate • Evaluate • Explain • Importance • Influence • Interpret • Judge • Justify • Mark • Measure • Opinion • Perceive • Prioritize • Prove • Rate • Recommend • Rule on • Select • Support • Value	• Adapt • Build • Change • Choose • Combine • Compile • Compose • Construct • Create • Delete • Design • Develop • Discuss • Elaborate • Estimate • Formulate • Happen • Imagine • Improve • Invent • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution • Solve • Suppose • Test • Theory

Anderson, L. W., & Krathwohl, D. R. (2001). A taxonomy for learning, teaching, and assessing, Abridged Edition. Boston, MA: Allyn and Bacon.

DadiInstituteofEngineeringandTechnology

EnvironmentalEngineering-IILectureMaterial

3-1(R19)

B.Tech-CivilEngineering(CE)

TERMINOLOGY

REFUSE:
This is the most general term to indicate the wastes which include all the rejects left as worthless,sewage,sullage–allthese terms areincludedinthisterm.

GARBAGE:
It is a dry refuse which includes, waste papers, sweepings from streets and markets, vegetablepeelings etc. The quantity of garbage per head per day amounts to be about .14 to .24 kg forIndian conditions. Garbage contains large amount of organic and purifying matter and thereforeshouldberemovedas quicklyaspossible.

RUBBISH:
It consists of sundry solid wastes from the residencies, offices and other buildings. Brokenfurniture,paper,ragsetcare includedinthisterm.It isgenerallydryandcombustible.

SULLAGE:
It is the discharge from the bath rooms, kitchens, wash basins etc., it does not include dischargefrom the lavatories, hospitals, operation theaters, slaughter houses which has a high organicmatter.

SEWAGE:
It is a dilute mixture of the wastes of various types from the residential, public and industrialplaces. It includes sullage water and foul discharge from the water closets, urinals, hospitals,stables,etc.

STORMWATER:
It is the surface runoff obtained during and after the rainfall which enters sewers through inlet.Storm water is not foul as sewage and hence it can be carried in the open drains and can bedisposedoffinthenaturalrivers withoutanydifficulty.

SANITARYSEWAGE:
Itisthesewageobtainedfromtheresidentialbuildings &industrialeffluentsestablishments.Beingextremelyfoulitshouldbe carriedthroughundergroundconduits.

DOMESTICSEWAGE:
It is the sewage obtained from the lavatory basins, urinals &water closets of houses, offices &institutions. It is highly foul on account of night soil and urine contained in it. Night soil startsputrefying&givesoffensivesmell.Itmaycontainlargeamountofbacteriaduetotheexcrementalw astesofpatients.Thissewage requiresgreathandling&disposal.

INDUSTRIALSEWAGE:
Itconsistsof spentwaterfromindustriesandcommercialareas.Thedegreeoffoulnessdependsonthenatureoftheindus tryconcernedandprocessesinvolved.

SEWERS:
Sewersareunderground pipeswhichcarrythesewageto apoint ofdisposal.

SEWERAGE:

Theentiresystemofcollecting,carrying &disposalofsewagethroughsewersisknownassewerage.

DRYWEATHERFLOW(DWF):
Domesticsewageandindustrialsewagecollectively,iscalledasDWF.
Itdoesnotcontainstormwater.Itindicates thenormalflowduringdryseason.

BACTERIA:
Thesearethemicroscopicorganisms.Thefollowingarethegroupsofbacteria:

- Aerobic bacteria:theyrequireoxygen&lightfortheirsurvival.
- Anaerobic bacteria:theydonotrequire freeoxygenandlightforsurvival.
- Facultativebacteria: theycanexistinthepresenceorabsenceofoxygen.Theygrowmoreinabsenceofair.

INVERT:
Itisthelowestpointoftheinterioroftheseweratanyc/s.

SLUDGE:
Itistheorganicmatterdepositedinthesedimentationtank duringtreatment.

UNIT–I

Introduction to sanitation – systems of sanitation – relative merits & demerits – collectionand conveyance of waste water – sewerage – classification of sewerage systems- Estimationof sewage flow and storm water drainage – fluctuations – types of sewers - Hydraulics ofsewers and storm drains– design of sewers – appurtenances in sewerage – cleaning andventilationofsewers.

TERMINOLOGY

REFUSE:
This isthemostgeneraltermtoindicatethewasteswhichincludealltherejectsleftas worthless,sewage, sullage–allthesetermsareincludedinthisterm.

GARBAGE:
It is a dry refuse which includes, waste papers, sweepings from streets and markets, vegetablepeelings etc. The quantity of garbage per head per day amounts to be about .14 to .24 kg forIndianconditions.Garbagecontainslargeamountoforganicandpurifyingmatterandtherefore shouldbe removedasquicklyas possible.

RUBBISH:
It consists of sundry solid wastes from the residencies, offices and other buildings. Brokenfurniture,paper,ragsetcareincludedinthisterm.It isgenerallydryand combustible.

SULLAGE:
It is the discharge from the bath rooms,kitchens,wash basins etc., itdoes not includedischarge from the lavatories, hospitals, operation theaters, slaughter houses which has a highorganicmatter.

SEWAGE:
It is a dilute mixture of the wastes of various types from the residential, public and industrialplaces. It includes sullage water and foul discharge from the water closets, urinals, hospitals,stables,etc.

STORMWATER:
It is the surface runoff obtained during and after the rainfall whichenters sewers throughinlet. Storm water is not foul as sewage and hence it can be carried in the open drains and canbe disposedoffinthenaturalriverswithoutanydifficulty.

SANITARYSEWAGE:
Itisthesewageobtainedfromtheresidentialbuildings&industrialeffluentsestablishments.Beinge xtremelyfoulitshouldbe carriedthroughundergroundconduits.

DOMESTICSEWAGE:
It is the sewage obtained from the lavatory basins, urinals &water closets of houses, offices &institutions. Itis highly foul on account of night soil and urine containedinit. Nightsoilstarts putrefying & gives offensive smell. It may contain large amount of bacteria due to theexcrementalwastesofpatients.Thissewagerequiresgreathandling&disposal.

INDUSTRIALSEWAGE:
It consists of spent water from industries and commercial areas. The degree of foulnessdependsonthe natureoftheindustryconcernedandprocessesinvolved.

SEWERS:
Ewersareunderground pipeswhichcarrythesewagetoapoint ofdisposal.

SEWERAGE:
Theentiresystemofcollecting,carrying &disposalofsewagethroughsewersisknownassewerage.

DRYWEATHERFLOW (DWF):
Domesticsewageandindustrialsewagecollectively,iscalledasDWF.Itdoesnotcontainstormwater.Itindicatesthenormalflow duringdryseason.

BACTERIA:
Thesearethemicroscopicorganisms.

Thefollowingarethegroupsofbacteria:Aerobicbacteria: theyrequire oxygen&lightfortheirsurvival.

Anaerobic bacteria:theydonotrequire freeoxygenandlightforsurvival.

Facultativebacteria: theycanexistinthepresenceorabsenceofoxygen.Theygrowmoreinabsenceofair.

INVERT:
Itisthelowestpointoftheinteriorofthesewer atanyc/s.

SLUDGE:
Itistheorganicmatterdepositedinthesedimentationtank duringtreatment.

CONCEPTS

Necessityforsanitation

Every community produces both liquid and solid wastes .The liquid portion – wastewater– is essentially the water supply of the community afterithas been fouledby a varietyofusessuchasspentwaterfrombathroomkitchen,lavatorybasins,houseandstreetwashings, from various industrial processes semi solid wastes of human and animal excreta,dry refuse of house and street sweepings, broken furniture, wastes from industries etc areproduceddaily**.**

If proper arrangements for the collection, treatment and disposal are not made, theywill go on accumulating and create foul condition. If untreated water is accumulating, thedecomposition of the organic materials it contains can lead to the production of large quantityof mal odorous gases. It also contains nutrients, which can stimulate the growth of aquaticplants and it may contain toxic compounds. Therefore in the interest of community of the cityor town, it is most essential to collect, treat and dispose of all the waste products of the city insuch a way that it may not cause any hazardous effects on people residing in town andenvironment.

Waste water engineering is defined as the branch of the environmental engineeringwhere the basic principles of the science and engineering for the problems of the waterpollution problems. The ultimate goal of the waste water management is the protection of theenvironmentalinmannercommensuratewiththeeconomic,socialand politicalconcerns.

Although the collection of stream water and drainage dates from ancient times thecollection of waste water can be treated only to the early 1800s. The systematic treatment ofwaste waterfollowedinthe1800sand1900s.

Importanceofseweragesystem

One of the fundamental principles of sanitation of the community is to remove alldecomposablematter,solid waste,liquid or gaseousawayfromthepremisesofdwellingsas fastaspossibleafteritisproduced,toasafeplace, withoutcausinganynuisanceanddisposeitinasuitablemannersoastomakeitpermanently harmless.

Sanitation though motivated primarily for meeting the ends of preventive health hascometoberecognizedas away of life.In this context,developmentof thesanitationinfrastructureofanycountrycouldpossiblyserveasasensitiveindexofitslevelofprosp erity. It is needless to emphasize that for attaining the goals of good sanitation, seweragesystem is very essential. While provision of potable drinking water takes precedence in theorderofprovisionofEnvironmentalEngineeringServices,theimportanceofseweragesystem cannot be last sight and cannot be allowed to lag behind, as all the water used by thecommunity has to flow back as the sewageloaded with the wastes of community living,unlessproperlycollected, treatedanddisposedoff ,thiswouldcreatea seriouswaterpollutionproblems.

Methodsofdomesticwastewaterdisposal:

Afterthewastewateristreateditisdisposedinthenatureinthefollowingtwoprincipal methods

a. DisposalbyDilutionwherelargereceivingwater bodiesareaavailableb. Landdisposalwheresufficientlandis available

The choice of method of disposal depends on many factors and is discussed later.Sanitaryenggstarts atthepointwherewatersupplyenggends.Itcanbeclassified as

Collection worksTreatment worksDisposalw orks

Thecollection consistsof collectingall typesof wasteproducts of town.Refuseiscollectedseparately.Thecollectionworksshouldbesuchthatwastematterscanbetra nsported quickly and steadily to the treatment works. The system employed should be selfcleaningandeconomical.

Treatment is required to treat the sewage before disposal so that it may not pollute theatmosphere & the water body in which it will be disposed of .The type of treatment processesdependonthenatureofthewastewatercharacteristicsandhygiene,aestheticsandeconomi calaspects.

Thetreatedwaterisdisposedofinvariouswaysbyirrigatingfieldsordischargingintonaturalwaterc ourses.

DifferentMethodsofdomesticwastewaterdisposalinclude(SystemsofSanitation):

1) CONSERVENCYSYSTEM
2) WATERCARRIAGE SYSTEM

CONSERVENCSYSTEM:

Sometimes the system is also called as dry system. This is out of date system but isprevailing in small towns and villages. Various types of refuse and storm water are collectedconveyed and disposed of separately. Garbage is collected in dustbins placed along the roadsfrom where it is conveyed by trucks ones or twice a day to the point of disposal. all the noncombustible portion of garbage such as sand dust clay etc are used for filling the low levelareas to reclaim land for the future development of the town. The combustible portion of thegarbageisburnt.Thedecayingmattersaredriedanddisposedofbyburningorthemanufactureofm anure.

Humanexcretaarecollectedseparatelyinconservancylatrines.Theliquidandsemiliquidwastes arecollectedseparatelyafterremovalofnightsoilitistakenoutsidethetownin trucks and buried in trenches. After 2-3 years the buried night soil is converted into excellentmanure.In conservancy system sewage and storm water are carried separately in closeddrains to the pointof disposal where they are allowedtomix with riverwater withouttreatment.

WATERCARRIAGESYSTEM

With development and advancement of the cities urgent need was felt to replaceconservancy system with some more improved type of system in which human agency shouldnotbeusedforthecollectionandconveyanceofsewage.Afterlargenumberof experimentsit was found that the water is the only cheapest substance which can be easily used for thecollection and conveyance of sewage. As in this system water is the main substance thereforeitis calledas WATERCARRIAGESYSTEM.

In this system the excremental matter is mixed up in large quantity of water their arstaken out from the city through properly designed sewerage systems, where they are disposedofafternecessarytreatmentinasatisfactorymanner.

The sewages so formed in water carriage system consist of 99.9% of water and .1%solids. All these solids remain in suspension and do not changes the specific gravity of watertherefore all the hydraulic formulae can be directly used in the design of sewerage system andtreatmentplants.

SEWERAGESYSTEMS:

CONSERVANCY SYSTEM	WATER CARRIAGE SYSTEM
Very cheap in initial cost.	It involves high initial cost.
Due to foul smells from the latrines, they are to be constructed away from living room so building cannot be constructed as compact units.	As there is no foul smell latrines remain clean and neat and hence are constructed with rooms, therefore buildings may be compact.
The aesthetic appearance of the city cannot be improved	Good aesthetic appearance of city can be obtained.
For burial of excremental matter large area is required.	Less area is required as compared to conservancy system.
Excreta is not removed immediately hence its decomposition starts before removal,	Excreta are removed immediately with water, no problem of foul smell or hygienic trouble.
This system is fully depended on human agency .In case of strike by the sweepers; there is danger of insanitary conditions in	As no human agency is involved in this system ,there is no such problem as in case of conservancy system

1) SEPARATESYSTEMOFSEWAGE
2) COMBINEDSYSTEMOFSEWAGE
3) PARTIALLYCOMINEDORPARTIALLYSEPARATESYSTEM

SEPARATESYSTEMOFSEWERAGE

In this system two sets of sewers are laid .The sanitary sewage is carried throughsanitary sewers while the storm sewage is carried through storm sewers. The sewage iscarriedtothetreatmentplantandstormwaterisdisposedoftothe river.

Advantages:

1) Sizeofthesewersaresmall

2) Sewage loadontreatmentunitisless
3) Riversarenotpolluted
4) Stormwater canbedischarged toriverswithout treatment.

Disadvantage

1) Seweragebeingsmall, difficultyincleaningthem
2) Frequentchokingproblemwillbetheir
3) Systemprovescostlyasitinvolvestwo setsof sewers
4) Theuse ofstormsewerisonlypartialbecauseindryseasonthe willbe convertedintodumpingplaces andmaygetclogged.

COMBINEDSYSTEMOFSEWAGE

Whenonlyonesetofsewersare used tocarrybothsanitarysewageandsurfacewater.This systemiscalledcombinedsystem.

Sewageand stormwaterbotharecarried tothetreatmentplantthroughcombinedsewers

Advantages:

1) Sizeofthesewersbeinglarge,chockingproblems arelessandeasytoclean.
2) Itproveseconomicalas1 set ofsewersarelaid.
3) Becauseofdilutionofsanitarysewagewithstormwaternuisance potentialisreduced

Disadvantages:

1) Sizeofthesewersbeinglarge, difficultyinhandlingandtransportation.
2) Loadontreatmentplantisunnecessarilyincreased
3) Itisuneconomicalifpumpingisneededbecauseoflargeamountofcombinedflow.
4) Unnecessarilystormwaterispolluted

PARTIALLYCOMINEDORPARTIALLYSEPARATESYSTEM

A portion of storm water during rain is allowed to enter sanitary sewer to treatmentplantswhiletheremainingstormwater iscarriedthroughopendrainstothepointofdisposal.**Advantages:-**

1. Thesizesofsewersare not verylarge assome portionofstormwateriscarriedthroughopendrains.
2. Combinestheadvantagesofboththeprevioussystems.
3. Siltingproblemiscompletelyeliminated.

Disadvantages:-

1. Duringdryweather,thevelocityofflowmaybelow.
2. Thestormwater isunnecessaryputloadontothetreatmentplantstoextend.
3. Pumpingofstormwaterinunnecessaryover-loadonthepumps.

Suitableconditionsforseparateseweragesystems:-

Aseparatesystemwouldbesuitableforuseunderthefollowingsituations:Whererainfallis uneven.

Wheresanitarysewageistobepumped.

Thedrainageareaissteep,allowingtorunoffquickly.

Sewersaretobeconstructedinrockystrata.Thelargecombined sewerswouldbemoreexpensive.

conditionsforcombined system:-

Rainfallineventhroughouttheyear.

Boththesanitarysewageand thestormwaterhavetobepumped.

Theareatobesewereddisheavilybuiltupandspaceforlayingtwosetsofpipesisnotenough.

Effectiveorquickerflowshavetobeprovided.

Afterstudyingtheadvantagesanddisadvantagesofboththesystems,presentdayconstructionofsewersis largelyconfinedtotheseparatesystemsexceptinthosecitieswhere combined system is already existing. In places where rainfall is confined to one season of theyear,likeIndiaand evenintemperateregions,separatesystemaremostsuitable.

Sl. no.	Separate system	Combined system
1.	The quantity of sewage to be treated is less, because no treatment of storm water is done.	As the treatments of both are done, the treatment is costly.
2.	In the cities of more rainfall this system is more suitable.	In the cities of less rainfall this system is suitable.
3.	As two sets of sewer lines are to laid, this system is cheaper because sewage is carried in underground sewers and storm	Overall construction cost is higher than separate system.
4.	In narrow streets, it is difficult to use this system.	It is more suitable in narrow streets.
5.	Less degree of sanitation is achieved in this system, as storm water is disposed without any treatment.	High degree of sanitation is achieved in this system.

SourcesofSewage:-

Sanitarysewageisproducedfromthefollowingsources:

1. When the water is supplied by water works authorities or provided from private sources, itis used for various purposes like bathing, utensil cleaning, for flushing water closets andurinals or washing clothes or any other domestic use. The spent water for all the above needsformsthesewage.
2. Industriesusethewater formanufacturingvariousproductsandthusdevelopthesewage.
3. Watersuppliedtoschools,cinemas,hotels,railwaystations,etc.,whengetsuseddevelopssewage .
4. Groundwaterinfiltrationintosewersthroughloose joints.
5. Unauthorizedentranceofrainwater insewerlines.

NatureofSewage:-

Sewage is a dilute mixture of the various types of wastes from the residential, publicand industrial places. The characteristics and composition i.e. The nature of sewage mainlydependsonthissource.Sewagecontainsorganicandinorganicmatterswhichmaybedissolved, suspension and colloidal state. Sewage also contains various types of bacteria,Virus, protozoa, etc. sewage may also contain toxic or other similar materials which mighthave got entry from industrial discharges. Before the design of any sewage treatmentplantthe knowledgeofthe natureofsewageis essential.

QuantityofSanitary SewageandStormWater:-

The determination of sanitary sewage is necessary because of the following factorswhichdependonthis:

1. Todesignthesewerageschemesaswellasto disposeatreatedsewageefficiently.
2. The size,shape anddepthofsewersdependonquantityofsewage.
3. Thesizeofpumping unitdependsonthequantityofsewage.

EstimateofSanitary Sewage:-

Sanitary sewage is mostly the spent water of the community into sewer system withsome groundwater and a fraction of the storm runoff from the area, draining into it. Beforedesigning the sewerage system, it is essential to know the quantity of sewage that will flowthroughthesewer.

Thesewagemaybeclassifiedundertwoheads:
1. Thesanitarysewage,and
2. Stormwater

Sanitary sewage is also called as the Dry Weather Flow (D.W.F), which includes thedomesticsewageobtainedfromresidentialandresidentialandindustrialsetc.,andtheindustrialsewageortradewastecomingfrommanufacturing unitsand otherconcerns.

Quantityof Sewage:-

It is usual to assume that the rate of sewage flow, including a moderate allowance forinfiltrationequalstoaveragerateofwaterconsumptionwhichis135litre/head/dayaccordingtoIndian Standards.Itvaries widelydependingon size of the townetc. thisquantity is known as Dry WeatherFlow(D.W.F).Itis thequantity of water thatflowsthroughsewerindryweatherwhennostormwaterisinthesewer.

Rate of flow varies throughout 24 hours andis usually the greatest in thefore-noonandvery small from midnighttoearly morning. For determining the size of sewer, themaximumflowshouldbetakenas threetimestheD.W.F.

DesignDischargeofSanitarySewage

The total quantity of sewage generated per day is estimated as product of forecastedpopulation at the end of design period considering per capita sewage generation andappropriate peak factor. The per capita sewage generation can be considered as 75 to 80% ofthepercapitawatersuppliedperday.Theincrease inpopulationalsoresultinincrease inpercapita water demand and hence, per capita production of sewage. This increase in waterdemand occurs due to increase in living standards, betterment in economical condition,changes in habit of people, and enhanced demand for public utilities. Factors affecting thequantityofsewageflow:-

Thequantityofsanitarysewageismainlyaffected bythefollowingfactors:
1. Population
2. Type ofarea
3. Rateofwatersupply
4. Infiltrationandexfiltration

In addition to above, it may also be affected by habits of people, number of industriesandwaterpressureetc.

The quantity of sanitary sewage directly depends on the population. As the populationincreases the quantity of sanitary sewage also increases. The quantity of water supply is equalto the rate of water supply multiplied by the population. There are several methods used forforecasting the population of a community. The quantity of sanitary sewage also depends onthe type of area as residential, industrial or commercial. The quantity of sewage developedfrom residential areas depend on the rate of water supply to that area, which is expressed alitres/capita/dayand thisquantityisobtainedbymultiplyingthepopulationwiththisfactor.

Thequantity of sewageproduced by variousindustries depends on theirvariousindustrial processes, which is different for each industry. Similarly the quantity of sewageobtained from commercial and public places can be determined by studying the developmentofothersuchplaces.

Rate ofwater

Truly speaking the quantity of used water discharged into a sewer system should be alittle less than the amount of water originally supplied to the community. This is because ofthe fact that all the water supplied does not reach sewers owing to such losses as leakage inpipes or such deductions as lawn sprinkling, manufacturing processes etc. However, theselossesmaybelargelybemadeupbysuchadditionsassurfacedrainage,groundwaterinfiltration, watersupplyfromprivatewells etc.Onanaverage,therefore,thequantityof sewage maybe considered to be nearly equal to the quantity of water supplied. Ground waterinfiltrationandexfiltration.

The quantity of sanitary sewage is also affected by groundwater infiltration throughjoints. The quantity will depend on, the nature of soil, materials of sewers, type of joints insewerline,workmanshipinlaying sewersand positionofundergroundwatertable.

Infiltration causes increase to the ―legitimate‖ flows in urban sewerage systems. Infiltrationrepresents a slow response process resulting in increased flows mainly due to seasonally-elevated groundwater entering the drainage system,and primarily occurring through defectsinthepipenetwork.

Exfiltration represents losses from the sewer pipe, resultingin reduced conveyanceflowsand is due to leaks from defects in the sewer pipe walls as well as overflow discharge intomanholes, chambers and connecting surface water pipes. The physical defects are due to acombination of factors including poor construction and pipe joint fittings, root penetration,illicitconnections,biochemical corrosion,soil conditions and trafficloadings as well asaggressive groundwater.

It is clear that Infiltration and Exfiltration involve flows passing through physicaldefects in the sewer fabric and they will often occur concurrently during fluctuations ingroundwater levels,and particularly in association with wetweather events; both of whichcan generate locally high hydraulic gradients. Exfiltration losses are much less obvious andmodestthaninfiltrationgains,andarethereforemuchmoredifficulttoidentifyandquantify.

However, being dispersed in terms of their spatial distribution in the sewer pipe,exfiltration losses can have potentially significant risks for groundwater quality. The episodicbutpersistentreverse ―pumping‖ effect of hydraulic gain andloss will inevitably lead tolong term scouring of pipe surrounds and foundations resulting in pipe collapse and evensurface subsidence.

Suggested estimates for groundwater infiltration for sewers laid below ground watertable areasfollows:

	Minimum	Maximum
Litre/ day/ hectare	5,000	50,000
Lpd/ km of sewer/cm dia.	500	5,000

Designperiod

Followingdesignperiodcanbeconsideredfordifferentcomponentsofseweragescheme.

1. Lateralslessthan15cmdiameter:Fulldevelopment
2. Trunkor mainsewers:40to50years
3. TreatmentUnits: 15to 20years
4. Pumpingplant:5to10years

Variationsinsewageflow:-

Thesewage flow,likethewatersupplyflow,isnotconstant inpractice butvaries. Thefluctuationmay,inasimilarway,beseasonalormonthly,dailyandhourly.

Variation occurs in the flow of sewage over annual average daily flow. Fluctuation inflow occurs from hour to hour and from season to season. The typical hourly variation in thesewage flow is shown in the Figure. If the flow isgauged nearits origin, the peak flow willbe quite pronounced. The peak will defer if the sewage has to travel long distance. This isbecause of the time required in collecting sufficient quantity of sewage required to fill thesewers and time required in travelling. As sewage flow in sewer lines, more and more sewageis mixed in it due to continuous increase in the area being served by the sewer line. This leadsto reduction in the fluctuations in the sewage flow and the lag period goes on increasing. Themagnitude of variation in the sewage quantity varies from place to place anditis verydifficulttopredict.

For smaller township this variation will be more pronounced due to lower length andtravel time before sewage reach to the main sewer and for large cities this variation will beless. The seasonal variations are due to climatic effect, more water being used in summer thanin winter. The daily fluctuations are the outcome of certain local conditions, involving habitsand customs of people. Thus, in U.S.A. and other European countries, Monday is the washingday, as such, amount of sewage flow would be much greater than on any other day. In India,however, Sundays or other holidays involve activities which permit greater use of water.Hourly variations are because of varying rates of water consumption in different hours of theday.

The first peak flow generally occurs in the late morning it is usually about 200 percentof the average flow while the second peak flow generally occurs in the early evening between6 and 9 p.m. and the minimum flow occurring during the night after twelve or early hours ofthe morningisgenerallyabouthalfofthe averageflow.

EffectsofFlowVariation onVelocityinaSewer

Due to variation in discharge, the depth of flow varies, and hence the hydraulic meandepth (r) varies. Due to the change in the hydraulic mean depth, the flow velocity (whichdepends directly on r2/3) gets affected from time to time. It is necessary to check the sewerfor maintaining a minimum velocity of about 0.45 m/s at the time of minimum flow (assumedto be 1/3rd of average flow). The designer should also ensure that a velocity of 0.9 m/s isdeveloped atleastat the time of maximum flow and preferably during the average flowperiods also. Moreover, care should be taken to see that at the time of maximum flow, thevelocitygenerateddoes notexceedthe scouringvalue.

Quantityofstormwater

When rain falls over the ground surface, a part of it percolates into the ground, a partis evaporated in the atmosphere andthe remainingpart overflows as storm water. Thisquantity of storm water is very large as compared with sanitary sewage. Factors affectingstormwater**:-**

Thefollowingare factorswhichaffectthe quantityofstormwater:

1. Rainfall intensityandduration.
2. Area ofthe catchment.
3. Slopeand shapeofthecatchmentarea.
4. Natureofthesoilandthe degreeofporosity.
5. Initialstateofthecatchment.

If rainfall intensity and duration is more, large will be the quantity of storm wateravailable. If the rainfall takes place very slowly even though it continues for the whole day,the quantity of storm water available will be less. Harder surface yield more runoff than soft,rough surfaces. Greater the catchment area greater will be the amount of storm water. Fanshaped and steep areas contribute more quantity of storm water. In addition to the above italsodepends onthetemperature,humidity,windetc.

Estimateofquantity ofstormwater:-

Generallytherearetwomethods bywhichthequantityofstormwateris calculated:

1. Rationalmethod
2. Empiricalformulae method

Inboththeabovemethods,thequantityofstormwateris afunctionofthearea,theintensityofrainfallandtheco-efficientofrunoff.

Rationalmethod:-

Runofffromanarea canbe determined bythe RationalMethod.Themethodgivesareasonable estimateuptoamaximumarea of50ha (0.5Km2).

AssumptionsandLimitations

Useoftherationalmethodincludesthefollowingassumptionsandlimitations:

Precipitation is uniform over the entire basin.Precipitationdoesnot varywithtimeorspace.

Stormdurationis equaltothetimeofconcentration.

Adesignstormofa specifiedfrequencyproducesa design floodofthe samefrequency.

Thebasinareaincreasesroughlyinproportiontoincreases inlength.

Thetimeofconcentrationisrelativelyshortandindependentofstormintensity.

Therunoffcoefficientdoesnot varywithstormintensityorantecedentsoil moisture.

Runoff is dominated by overlandBasinstorageeffectsarenegl igible.

The minimum duration to be used for computation of rainfall intensity is 10 minutes. Ifthe time of concentration computed for the drainage area is less than 10 minutes, then 10minutes should be adopted for rainfall intensity computations. This method is mostly used indetermining the quantity of storm water. The storm water quantity is determined by therationalformula:

Q = ———

SEWERDESIGN

Designphilosophy

A sewer system is a network of pipes used to convey storm runoff and/or wastewaterin an area. The design of sewer system involves the determination of Diameters, Slopes, andCrownorinvertelevationsforeachpipeinthesystem.

Constraintsandassumptions

Freesurfaceflowexitsforthedesigndischarges; thatis,thesewersystemisdesigned for "gravity of low"; pumping stations and pressurized sewers should be avoided asmuchas possible(are notconsideredhere).

The sewers are of commercially available circular sizes. The design diameter is thesmallest commercially available pipe having f low capacity equal to or greater than the designdischarge andsatisfyingalltheappropriate constraints

Sewers must be placed at a depth such that theyWill not be susceptible to frost, Will be able todrainbasements,and Willhavesufficientcushioningtoprevent breakageduetogroundsurface loading.Tothese ends,minimumcoverdepthsmustbe specified.

Thesewersarejoinedatjunctionssuchthatthecrownelevationoftheupstreamsewerisnolowerthed ownstreamsewer

To prevent or reduce excessive deposition of solid material in the sewers, a minimumpermissible flow velocity at design discharge or at barely full-pipe gravity flow I specified Toprevent scour and other undesirable effects of high- velocity f low, a maximum permissibleflow velocityis alsospecified

Atanyjunctionor manhole,thedownstreamsewercannotbesmallerthananyoftheupstreamsewers atthatjunction

Thesewersystemisadendritic, orbranching, networkconverginginthedownstreamdirectionwithoutclosedloops

Design Steps

Step1-Topographicalmap

Obtainordevelopamapofthecontributing area
Addlocationandlevelofexistingorproposeddetailssuchas:Contours

Physicalfeatures(e.g.rivers)R
oadlayout
Buildings
Sewersandotherservices
Outfallpoint(e.g.nearlowestpoint,nexttoreceivingwaterbody)
Step2- Preliminaryhorizontallayout
Sketchpreliminarysystemlayout(horizontalalignment):
Locatepipessoallpotentialuserscanreadilyconnectintothe
systemTrytolocate pipes perpendiculartocontours
Trytofollow naturaldrainage patterns
Locatemanholes inreadily-accessiblepositions
Step3-Preliminarysewersizing
Establishpreliminarypipesizesandgradients
Step4- Preliminaryverticallayout
Drawpreliminarylongitudinalprofiles(verticalalignment):
EnsurepipesaredeepenoughsoalluserscanconnectintothesystemTrytol
ocatepipesparalleltothe groundsurface
EnsurepipesarriveaboveoutfalllevelAv
oid pumpingifpossible
Step 5-Revise layout
Revisethe horizontaland/or verticalalignment tominimizesystemcostbyreducing
pipe:Lengths
SizesD
epths
Designofcertria
The followingcriterianeedtobeformulatedfordesignofsewersystems:
Peak rates of dry weather f low (wastewater + groundwater infiltration) heavy producers
ofallowanceforillicitrainwaterconnectionstosanitarysewersdesignstormrunoffcoefficient.Pipe
profiles (andmaterials)
Hydraulic
frictionconstantsMinimums
lopesofsewers
Outletlevels(maximumwaterlevel,invertforstormwater)
Infiltrationtosewerpipes
Assumespecificrateofgroundwaterinfiltration(inl/s/ha)forsewerswiththeirinvertlocated
belowthegroundwatertable
Allowance
forillicitinflowCompileavaila
blesewersizes**Stormwaterqu
antities**
Theamountofstormwaterto betransportedisdetermined
withtherationalmethod.Indicate whatdesign frequency(returnperiod)isused
Determinetherainfallintensity-
durationcurvefortherequiredfrequencyIndicaterunoffcoefficients
Determine the hydraulic performance of
selectedprofilesEstablishpartialflowdiagramsifnecessar
y**Designofsanitarysewer systems**
Publicsanitarysewersperformtwoprimaryfunctions:
Safelycarrythedesignpeakdischarge,
Transportsuspendedmaterialstopreventdepositioninthesewer.Indesigningasewersystem,thedesi

gnermustconductpreliminaryinvestigations,reviewdesignconsiderationsandselectbasic designdataandcriteria, Design the sewers which include preparation of a preliminary sewer system and design ofindividualsewers,and

Preparecontract drawingsandspecifications.

Comprehensive preliminary investigations of the area to be served are required not only toobtain the data needed for design and construction but also to record pertinent informationaboutthe localconditionsbefore constructionbegins.These are

Mapsand otherdrawingsofthearea;

Locationsofstreets,alleys,railwayspublicparksandbuildings, ponds,streams,drainage ditches and other features and structure which may be influenced orinfluence thesewersystems;

A benchmarkoneachblockofeverystreet;

Ifpossiblecontoursatsuitableintervals,highandlowpointsandchanges insurfaceslopes;

Localrainfallandrunoffdata, ifany,otherwisemeasurementsinthefieldshouldbetaken;

Characterofthe soilinwhichthesewersare toconstruct;andLocalwages ofunskilledandskilledlabor.

Designing a sanitary sewer involves estimation of waste flow rates for the design data andevaluation of anylocal conditions,whichmay affectthe hydraulic operation of the system;the selection of the hydraulic-design equation, alternative sewer pipe materials and minimumandmaximumsizes,minimumandmaximumvelocitiesandslopes;theevaluationofalternative alignments ordesigns.

*Designflow:*Peakhourlyflowandpeakinfiltrationallowances fortheentireserviceareaareusedforthedesignofnewsanitarysewers.

*Hydraulicdesignequation:*Manningequationsarecommonlyused.

$v=$

DesignProcedures

Layout the sewer: Draw a line to represent the proposed sewer in each street or alley to beserved. Near of on the line; indicate by an arrow the direction in which the wastewater is toflow. Except in special cases, the sewer should slope with the surface of the street. It isusually more economical to plan the system so that the wastewater from any street will flowtothepointofdisposalbythemostdirect(and, consequently;theshortest)route.Ingeneral,the laterals connect with the mains and these; in turn connect with the trunk sewer, whichleads to the point of discharge or to an intercepting sewer. Locate the manholes: Locate amanhole at:

(1) Changesindirection;

(2) Changesinslope;

(3) Atpipejunctionswiththeexceptionofbuildingconnections;

(4) Attheupperendandendsofalllaterals forcleansingandflushingthelines;and

(5) Atintervalsfrom90to120mor less,asrequired.Giveeachmanholeanidentificationnumber.

Establishing the limits of the service area: Sketch the limits of the service areas. Search thelimits of the service area for each lateral. If a single lateral will be required to accommodatean area larger than can be served by the minimum size of sewer with the minimum slope thearea should be subdivided further. Where the streets are laid out assume that the limits aremidway between them. If the street layout is not shown on the plan, the limits of the differentserviceareascannotbedeterminedascloselyand the topographymayserveasaguide.

Determinethearea ofeachservicearea.Measurethe areaofeachservice areabyusingascale,andenterthe valueonthemap.

1. Summarizethebasicdesigncriteria.
a.
Designperiod(usuallysaturationperiodused
);b.Populationdensity;
c. Residentialwastewaterflow(Obtainthepeakingfactor);
d. Infiltrationallowances;
e. Inflowallowances
f. Hydraulicdesignequation;
g. Minimumpipesize;
h. Minimumvelocity;and
i. Minimumcover.
Prepare tabulation form to record the data and steps in the compilations for each section ofsewerbetweenManholes.

Minimumslopesofsewers

Toassurethatsewerswillcarrysuspendedsediment,twoapproaches havebeenused:Theminimum(orself-cleansing)velocityand Theminimumboundaryshearstress method,alsocalledthe"tractiveforce" Self-cleansing -afull-pipevelocityofatleast0.6m/sMinimumslopesofsewers

Toassurethatsewerswillcarrysuspendedsediment,twoapproaches havebeenused: The minimum (or self-cleansing) velocity and the minimum boundary shear stress method,alsocalled"tractiveforce"self-cleansing -afull-pipevelocityofatleast0.6 m/s

Designofstormsewers

Generally,stormsewersaredesignedto providesafepassageofvehicles,andto collect,conveyanddischargeforfrequently occurring,low-return-period storms.Storm sewerdesigninvolvesestimationrunofffromanarea design of the sewer and otherhydraulicsstructures inthe drainagesystem.

Designflow

*Designflow*isthemaximumflowthatcanpassthroughaspecifiedstructuresafely.Indetermining this design flow the possibility of occurrence has be fixed. Once this is fixed thedesignflowmagnitude canbedetermined.

Generally,a design frequency is selected to match the facility's cost, amount oftraffic, potential flood hazard to property, expected level of service, political considerations,and budgetary constraints, considering the magnitude and risk associated with damages fromlargerfloodevents.

The frequency with which a given flood can be expected to occur is the reciprocal ofthe probability or chance that the flood will be equaled or exceeded in a given year. If a floodhas a 20 percent chance of being equaled or exceeded each year, over a long period of time,the flood will be equaled or exceeded on an average of once every five years. This is calledthe **Recurrence Interval**(RI).Thusthe exceedence probabilityequals100/RI.

Generally, todesigndrainagefacilitiestherecurrenceintervalshownintablecanbe used.

TableReturnPeriod BasedonTypeofStructures.

Drainage Type	Return Period
Side Ditch	10
Pipe Culvert	10
Slab/Box Culvert	25
Bridge	50/100

Thecommonlyusedhydrologicmethodsusedtoestimatearethefollowing:
• **RationalMethod**-onlyfordrainage areaslessthan50 hectares(0.5kilometer2);
• **SCS andotherUnitHydrograph Methods**-fordrainageareasgreaterthan50hectares;
• **SuitableComputerPrograms**- suchasHYDRAIN'sHYDRO,HEC1,andTR-20willbeusedtofacilitate tedious hydrologiccalculations.

RationalMethod

Runofffromanarea canbedeterminedbythe RationalMethod.Themethodgivesareasonable estimateuptoamaximumarea of50ha (0.5Km2.

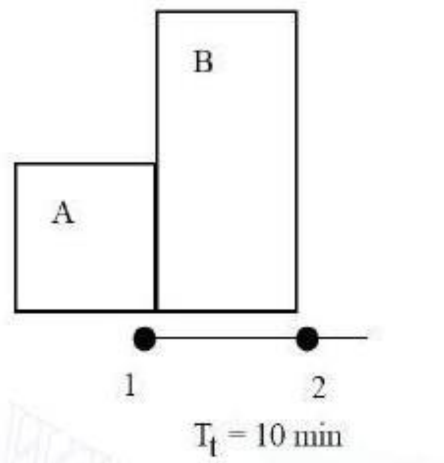
Therationalmethodmakesthefollowingassumptions:
• Precipitationisuniformovertheentirebasin.
• Precipitationdoesnot varywithtime orspace.
• Stormdurationis equaltothetimeofconcentration.
• Adesignstormofaspecifiedfrequencyproducesadesign flood ofthesamefrequency.
• Thebasinareaincreasesroughlyinproportiontoincreases inlength.
• Thetimeofconcentrationisrelativelyshortandindependentofstormintensity.
• Therunoffcoefficientdoesnotvarywithstormintensityorantecedentsoilmoisture.
• Runoffisdominatedbyoverlandflow.
• Basinstorageeffectsarenegligible.

Thus,thepeakrunoffiscalculatedaccordingtothefollowingformula:Where,
Q= runoff[m3/s]

Q=CiA/360

C=runoffcoefficientwhichcanbegivenfor alanduseor surfacetypei= designrainfallintensity[mm/hr]A= area[ha]

Example A storm sewer is proposed to drain a 12 hectares drainage area shown in the figurebelow. With given data in the table below determine the design discharge needed to convey5-yearpeakdischarge.



Site	Area (ha)	C	Inlet time (min)
A	4	0.8	10
B	8	0.5	30

Solution

UpstreamArea(Manhole1
):A=4ha

$C = 0.8$

$t_c = 10$ min

$i = 2700/(10+15) = 108$ mm/hr

$Q_p = CiA/360 = (0.8)(108)(4)/360 = 0.96$ m^3/sec

Downstream Area (Manhole 2):

$A = 4 + 8 = 12$ ha

$C = (0.8 \times 4 + 0.5 \times 8)/\ 12 = 0.6$

Time from A – 1 – 2 = 10 + 10 = 20 min

Time from B – 2 = 30 min (**max**)

$t_c = 30$ min

$i = 2700/(30+15) = 60$ mm/hr

$Q_p = CiA/360 = (0.6)(60)(12)/360 = 1.2$ m^3/sec

Appurtenancesinsewerage

Thestructures,whicharconstructedatsuitableintervalsalongtheseweragesystemtohelpitsefficientoperationandmaintenance,arecalledassewerappurtenances.Theseinclude:

(1) Manholes,
(2) Dropmanholes,
(3) Lampholes,
(4) Clean-outs,
(5) StreetinletscalledGullies,
(6) Catchbasins,
(7) FlushingTanks,
(8) Grease&Oiltraps,
(9) InvertedSiphons,and
(10) StormRegulators.

UNIT-2

Introduction

There are certain locations where it is possible to convey sewage by gravity to a centraltreatment facility or storm water is conveyed up to disposal point entirely by gravity. Whereas, incase of large area being served with flat ground, localities at lower elevation or widely undulatingtopography it may be essential to employ pumping station for conveyance of sewage to centraltreatment plant. Sewage and storm water is required to be lifted up from a lower level to a higherlevel at various places in a sewerages system. Pumping of sewage is also generally required at thesewagetreatmentplant.

Pumpingofsewageisdifferentthanwaterpumpingduetopollutednatureofthewastewater containing suspended solids andfloating solids, which may clog the pumps. Thedissolved organic and inorganic matter present in the sewage may chemically react with the pumpand pipe material and can cause corrosion. The disease causing bacteria present in the sewage maypose health hazard to the workers. Sedimentation of organic matter in the sump well may lead todecomposition and spreading of foul odour in the pumping station, requiring proper design toavoiddeposition.Also,variationofsewageflow withtimemakesitachallengingtask.

Pumpingstationsare oftenrequiredforpumpingof

(1) untreateddomesticwastewater,(2)stormwaterrunoff,(3)combineddomesticwastewatera ndstormwaterrunoff,(4)sludgeatawastewatertreatmentplant,(5)treateddomestic wastewater, and (6) recycling treated water or mixed liquor at treatment plants. Eachpumpingapplicationrequiresspecificdesignandpumpselectionconsiderations.Atsewagetreatme nt plant pumping is also required for removal of grit from grit chamber and pumping mayberequiredforconveying separatedgreaseand floatingsolids todisposalfacility.

Generally pumping station should contain at least three pumping units of such capacity tohandle the maximum sewage flow if the largest unit is out of service. The pumps should beselected to provide as uniform a flow as possible to the treatment plant. All pumping stationsshould have an alarm system to signal power or pump failure and every effort should be made toprevent or minimize overflow. Flow measuring device such as venturimeter shall be provided atthe pumping station. In all cases raw-sewage pumps should be protected by screens or racks unlessspecial devices such as self cutting grinder pumps are provided. Housingfor electricmotorsshould be made above ground and in dry wells electric motors should be provided protectionagainst flooding. Good ventilation in dry well should be provided, preferably of forced air type,andaccessibilityforrepairsandreplacementsshouldbeensured.

The site selection for the pumping station is important and the area selected should neverget flooded. The station should be easily accessible in all weathers. The storm water pumpingstation should be so located that the water may be impounded without causing damage to theproperties. Location of the pumping station shouldbe finalizeconsidering thefuture expansionandexpectedincreaseinthesewageflow.Thereneedtobeenoughspaceinthepumpingstationto replace low capacity pump with higher capacities as per the need in future. The capacity of thepumping station is based on the present and future sewage flow. Generally design period up to 15years is considered for pumps. The civil structure and the pipelines shall be adequate to serve forthedesignperiodof30years.

TypesofPumps

Followingtypesofpumpsareusedinthesewerages ystemforpumpingofsewage,sewage sludge,gritmatter,etc.asperthesuitability:a.Radial-flow centrifugalpumps

b. Axial-flowand mixed-flowcentrifugalpumps
c. Reciprocatingpistonsorplungerpumps
d. Diaphragmpumps
e. Rotaryscrew pumps
f. Pneumaticejectors
g. Air-liftpumps

Otherpumpsandpumpingdevicesare available,but theiruse inenvironmentalengineeringisinfrequent.

Radial-Flow Centrifugalpumps:

These pumps consist of two parts: (1) the casing and (2) the impeller. The impeller of thepump rotates at high speed inside the casing. Sewage is drawn from the suction pipe into the pumpand curved rotating vanes throw it up through outlet pipe because of centrifugal force. Radial-flowpumps throw the liquid entering the center of the impeller out into a spiral volute or casing. Theimpellers of all centrifugal pumps can be closed, semi open, or open depending on the application.Open impeller type pumps are more suitable because suspended solids and floating matter presentin the sewage can be easily pumped without clogging. These pumps can have a horizontal orvertical design. These pumps are commonly used for any capacity and head. These pumps havelow specificspeed up to4200.

Axial-flow Centrifugalpumps:

Axial-flow designs can handle large capacities but only with reduced discharge heads.They are constructed vertically. The vertical pumps have positive submergence of the impeller.These are used for pumping large sewage flow, more than 2000 m^3/h and head up to 9.0 m. Thesepumps have relatively high specific speed of 8000 – 16000. The water enters in this pump axiallyandtheheadisdevelopedbythepropelling actionof theimpellervanes.

Mixedflowpumps:

Thesepumpsdevelopheadsby combinationof centrifugal action andtheliftof theimpeller vane on the liquid. They are having single impeller. The flow enters the pump axially anddischarges in an axial and radial direction into volute type casing. The specific speed of the pumpvaries from4200to9000. Theseareusedfor mediumheads rangingfrom8 mto15m.

Mostwaterandwastewatercanbepumpedwithcentrifugalpumps.Theyshouldnotbeusedforthefollowing:

- Pumpingviscousindustrialliquidsorsludges,wheretheefficienciesofcentrifugalpumpsareverylow, andthereforepositivedisplacementpumps areusedfor suchapplications.
- Lowflowsagainsthigh heads.Exceptfordeep-well applications, thelargenumberof impellersneededisadisadvantagefor thecentrifugaldesign.

The rotational speed of impeller affects the capacity, efficiency, and extent of cavitation.Even if the suction lift is within permissible limits, cavitations can be a problem and should bechecked. Centrifugal pumps are classified on the basis of their specific speed (Ns) at the point ofmaximum efficiency. The specific speed of the pump is defined as speed of the impeller inrevolution per minute such that it would deliver discharge of 1 m3/min against 1.0 m of head; anditisdetermined using thefollowing equation:

$$Ns = \frac{3.65n\sqrt{Q}}{H^{0.75}}$$

Where,Q=flowinm3/min;H =Headinm;andn=speedinrpm.

The pumps with low specific speed are suitable for more suction lift than the pumps withhigh specific speed. The axial flow pumps with high specific speed will not work with any suctionlift; rather these pumps require positive suction head and some minimum submergence for troublefree operation. It is advisable to avoid suction lift for the centrifugal pumps. Hence pumps aregenerally installed either to work submerged in the wet well or installed in the dry well at such alevelthattheimpeller willbebelowthelevelofthelliquidinthewetwell.

Positivedisplacementpumps:

These pumps include reciprocating piston, plunger, and diaphragm pumps. Almost allreciprocating pumps used in environmental engineering are metering or power pumps. A piston orplunger is used in a cylinder, which is driven forward and backward by a crankshaft connected toan outside driving unit. Adjusting metering pump flow involves merely changing the length andnumber of piston strokes. A diaphragm pump is similar to a reciprocating piston or plunger, butinsteadof a piston,it contains a flexible diaphragm that oscillates as the crankshaft rotates.Plunger and diaphragm pumps feed metered amounts of chemicals (acids or caustics for pHadjustment) to a water or wastewater stream. These are not suitable for sewage pumping becausesolids and rugs present in the sewage may clog them. These pumps have high initial cost and verylow efficiency.

RotaryScrewPumps:

In this type, a motor rotates a vane screw or rubber stator on a shaft to lift or feed sludge orsolid waste material to a higherlevel or the inlet of another pump. These are used in the squaregritchamberfor removalofgrit.

AirPumps:

These pumpsinclude pneumatic ejectors and airlifts. In pneumatic ejector wastewaterflows into a receiver pot and an air pressure system then blows the liquid to a treatment process ata higher elevation. The air system can use plant air (or steam), a pneumatic pressure tank, or an aircompressor.Thispumpingsystemhasnomovingpartsincontactwiththewaste;thus,noclogging of impeller is involved. Ejectors are normally maintenance free and operate for longertime. Airlift pumps consist of an updraft tube, an air line, and an air compressor or blower. Airliftsblow air at the bottom of a submerged updraft tube. As the air bubbles travel upward, they expandreducing density and pressure within the tube. Higher flows can be lifted for short distances in thisway. Airlifts are used in wastewater treatment to transfer mixed liquors or slurries from oneprocess to another. These pumps havevery low efficiency and can lift the sewage up to smallhead.

EfficienciesofPumps

Efficiencies of the pumps range from 85%for large capacity centrifugals (radial-flowcentrifugalsand axial-flow and mixed-flow centrifugals)to below 50%for many smaller units.For reciprocating pistons or plunger pumps efficiency varies from 30% onward depending onhorsepower and number of cylinders. For diaphragm pumps, efficiency is about 30%, and forrotaryscrewtype,pneumaticejectors typeandair-liftpumps itis below25%.

Materials forConstructionofPumps

Forpumpingofwaterusingradial-flowcentrifugalsandaxial-flowandmixed-flowcentrifugal type pumps normally bronze impellers, bronze or steel bearings, stainless or carbonsteel shafts, and cast iron housing is used. For domestic wastewater pumping using radial -flowcentrifugalsand axial-f0lowand mixed-flowcentrifugal type pumpssimilar material isusedexceptthattheyareoftenmadefromcastironorstainlesssteelimpellers.Forindustrialwastewater and chemical feeders using radial -flow centrifugal or reciprocating piston or plungertype pumps, a variety of materials depending on corrosiveness are used. In diaphragm pumps thediaphragm is usually made of rubber. Rotary screw type, pneumatic ejectors type and air-liftpumps normallyhavesteelcomponents.

PumpingSystemDesign

To choose the proper pump, the environmental engineer must know the capacity, headrequirements,andliquidcharacteristics.Thissectionaddressesthecapacityandheadrequirements.

Capacity

To compute capacity, the environmental engineer should first determine average system flow rate,then decide if adjustments are necessary. For example, when pumping wastes from a communitysewage system, the pump must handle peak flows roughly two to five times the average flow,depending on community size. Summer and winter flows and future needs also dictate capacity.Population increase trends and past flow rates should also be considered in this evaluation. Thecapacity of the pumping station should be so determined that the pump of minimum duty shouldalso run for at least 5 min. In addition, the capacity of the well should be such that with anycombination of inflow and pumping, the cycle of operation for each pump will not be less than 5minand themaximumdetention timeinthewetwellwillnotexceed 30minataverageflow.

Thecapacityofthepumpsinstalledshouldmeetthepeakflowratewithabout100%standby. Twoormorenumberofpumpsshouldbeprovided.Thesizeandnumberofpumpsforlargerpumpingstation issoselectedthatvariationintheflowratecanbeadjustedbymanipulatingspeedofthepumporthrottlingthe deliveryvalve,withoutstartingorstoppingthepumpstoofrequently.Thegeneralpracticeistoprovidethre epumpingsetsinsmallstationsconsistingofonepumpofcapacityequaltodryweatherflow(DWF),second pumpwithcapacityof2timesDWFand third pumpof capacity 3 timesDWF. For larger pumping stationsfive pumpsetsareprovided with capacities of 2 units of 0.5 DWF, 2 pumps of 1 DWF and one pump of 3 DWF.**Head Requirement**

Headdescribespressureintermsoflift.Thedischargeheadonapumpisasumofthe followingcontributingfactors:

1) StaticHead(hd) - Theverticaldistancethroughwhichtheliquidmustbeliftedi.e.thelowestwaterlevelin wetwelland highestpointonthedischargeside.

2) Friction Head (hf) - The resistance to flow caused by friction in the pipes, valves, and bends.Entrance and transition losses shall also be included. The loss of head in friction in the pipes isestimatedfromthewellknownequationhf=fLv2/(2gD)

3) VelocityHead(hv) -The headrequiredtoimpart energyintoafluidtoinducevelocity.

Normallythishead isquitesmallandcanbe ignored unlessthetotalheadislow.Thisisestimatedas $v2/2g$.
4) Pressure Head (hp) - The pressure differential that the pump must develop to deliver water onthe delivery side under higher pressure. The pressure on water in sump well is usually atmosphericpressure,whereaswhen pumpinginto sewerstherewouldbepotentialheadatthepointofdelivery, against which the pump have to deliver. Thus, this is the difference between pressures ontheliquidin thewetwelland atthepointofdelivery.

TotalHead(H)ofpumpingisthusexpressedbythefollowingequation:

$$H = hd + hf + hv \pm hp \quad (2)$$

SuctionLift

The amount of suction lift that can be handled must be carefully computed. It is limited bythe barometric pressure (which depends on elevation and temperature), the vapor pressure (whichalso depends on temperature), friction and entrance losses on the suction side, and the net positivesuction head (NPSH) - a factor that depends on the shape of the impeller and is obtained from thepumpmanufacturer.

Horsepower

Thehorsepowerrequiredtodrivethepumpiscalledbrake horsepower(BHP).Thefollowingequationdetermines thebrakehorsepower:BHP $=(w.Q.H)/(75.\eta p.\eta m)$(3)

Where,Q =discharge(m3/s);H =headofwater(m);w =Densityofwater(kg/m3);ηp=Efficiencyofthepump;and ηm=efficiencyofthedrivingmotor.

TypesofPumpingStations

Pumping stations can be configured in a wide variety of arrangements, depending on sizeandapplication.The classificationsforsuch pumping-station configurationsare: wet well/drywell,wetwellonlywithsubmersiblepumps, and wetwellonlywithnon-submersiblepumps.

Wetwellanddrywell:

In this configuration, two pits (wells) are required: one to hold the fluid, and one to housethe pumps and appurtenances (Figure 9.1). This is required for fluids that cannot be primed orconveyed long distances in suction piping, this option is typically used to pump large volumes ofraw wastewater, where uninterrupted flow is critical and wastewater solids could clog suctionpiping. While construction costs of this type may be higher and a heating, ventilation, and cooling(HVAC) system is necessary due to installation below ground. This configuration is best foroperationandmaintenanceactivities becauseoperators canseeandtouchtheequipment.

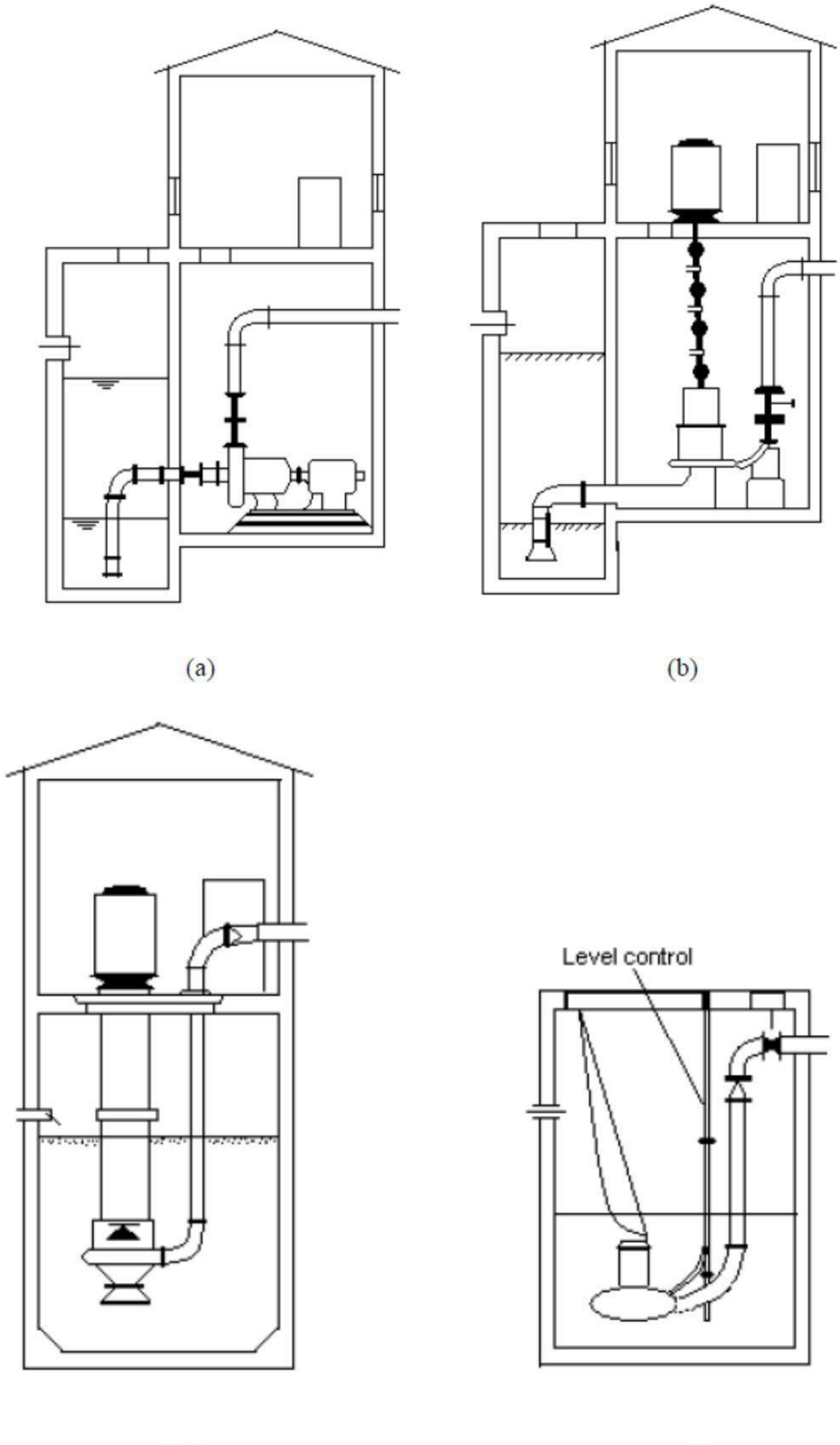
Wetwellwith submersiblepumps:

In this configuration, one well holds both the pumps and the wastewater being pumped. The pumpimpeller is submerged or nearly submerged in the wastewater. Additional piping is not required inthis type to convey the wastewater to the impeller. This option is common worldwide, and thesubmersiblecentrifugalpumpscanbeinstalledandoperatedcost-effectively.Whenverticalpumpsareinstalledthedrivingmotoris mountedonthefloorabovetheceilingofthewetwell.

Wetwellwith non-submersiblePumps:

In this configuration, one well holds the wastewater. The pumps are installed above thewater level in wet well. This option is used in areas where the wastewater can be “pulled” throughsuctionpipinge.g.,treatedorfinishedwaterorwhereshutdownsorfailureswouldnot beimmediatelycriticale.g.,apackageplant'srawwastewaterliftstations,equalizationofsecondary treated wastewater, etc. In selecting the best design for an application, environmentalengineers shouldconsider thefollowingfactors:

- Many gases are formed by domestic wastewater, including some that are flammable. Whenpumps or other equipment are located in rooms below ground level, the possibility of explosion orgas buildup exists,and ventilationisextremelyimportant.
- When wastewater is pumped at high velocities or through long lines, the hammering caused bywater can be a problem. Valves and piping should be designed to withstand these pressure waves.Evenpumpsthatdischargeto theatmosphere shouldusecheckvalvestocushionthe surge.Coarsebarscreensshall beprovidedaheadof pumpingstation when centrifugal pumpsareinstalled.
- Most of the places dry-well design is preferred. The pumping station must be able to adjust thevariation of wastewater flow. The smallest capacity pump should be able to pump from the wetwell and discharge at a self cleansing velocity of about 0.6 m/s. Pumping stations typically includeat least two pumps and a basic wet-well level control system. One pump is considered a “standby”pump, although the controls typically cycle back and forth during normal flows so they receiveequalwear.



(a) (b)

(c) (d)

FigurePumpingstations(a)Pumpingstationwithhorizontalpumpsinstalledindrywell, (b) Pumping station with vertical pump in dry well, (c) Pumping station with vertical pumps inwetwell, and (d) Wetwellwithsubmersiblesewagepump

Example:1

A per capita water demand of a township is 200 LPCD having total population of 50000 persons.The sewage generated from this town is required to lifted for 10 m of static head and 100 mdistance.Considerlossofheadinbendsandvalvesof0.4m.Determine(a)sizeofthesumpwell, (b) horsepower required for the pump, (c) diameter of the rising main. Assume suitable datarequired.

Solution

Estimationofsewageflowconsideringsewagegenerationequalto80%ofthewater supply

Average sewage flow = 50000 x 200 x 0.8 x 10^{-3} = 8000 m3/d = 0.093 m^3/sPeak sewage flow, considering peak factor of 3 = 0.278 m^3/s

Consideringvelocityof1 m/sinrisingmain, diameter required

$$D = \sqrt{\frac{0.278x4}{\pi}} = 0.595 \text{ m}$$

Providediameterof0.6m,henceactualvelocity=0.278*4/(πD^2)=0.984m/s

Designofsumpwell

Designthesumpforminimumtimeof15minforanypumptoruncontinuously.Quantityofsewage= 0.278 *60*15 = 250.2 m^3

Quantityofsewageinrising main =(πD^2)*L/4= π*0.6^2*100/4= 28.26m^3Netstoragecapacityofthesump = 250.2 +28.26= 278.46 m^3

Provide3sumpunits,twoforstorageofsewageandoneas standby,witheffectivewaterdepthof 3.0 m.Hencethesurfaceareaofeachsump = 250.2/(2*3) = 41.7m^2

Provide circular or rectangular shaped three sump wells each having surface area of 41.7 m^2 anddepthof3.0 m.

Checkfordetentiontimeofsewageinthesumpataverageinflow =volume/flow =41.7*3/(0.093 *60)=22.42min(less than30min,henceacceptable)

Checkfor minimum durationofpumping

Ifpumpwiththemaximumdischargeof0.278m3/s(peakflow)isoperated,Themaximumdurationofstorageataverageflow=30 min

Volumeofsewagecollected ataverageflow=0.093x60 x30 =167.4 m^3

Hencedurationofpumpingfor maximumcapacitypump= 167.4/(0.278x 60)=10minHence,forlower capacitypump thecontinuousdurationofoperationwillbemorethan10 min,whichisgreaterthanminimumoperation durationof5min.

Powerofpump

Consideringfrictionfactorof0.04,thefrictionalheadloss =hf=fLv^2/(2gD)

=0.04 *100*(0.984)2/(2*9.81*0.6)

=0.33 m

Velocity head = v2/2g = (0.984)2/ (2 * 9.81) = 0.05 mTotalhead ofpumping =10 +0.33+ 0.4+0.05= 10.78m

Considering efficiency of pump = 65% and efficiency of motor = 75%; hence HP of motorrequired for highest capacity pump (to be able to pump peak flow) = 0.278 x 1000 x 10.78 / (75 x0.65 x 0.75) = 82 HP

Provide minimum 3 pumps one with 82 HP to handle peak flow alone and other two pumps ofcapacity to handleof 1 DWF and 2 DWF. Thepower required for these pumps need to becalculated considering discharge for each pump, and hence the change in velocity and head loss,andfollowingthesimilar procedureasmentionedabove.

UNIT-III

3.1 SewageCharacteristics

Characterization of wastes is essential for an effective and economical waste managementprogram.It helps in the choice of treatment methods deciding the extent of treatment, assessingthe beneficial usesof wastes and utilizing the waste purification capacity of natural bodiesofwater in a planned and controlled manner. While analysis of wastewater in each particular case isadvisable,datafromtheother cities maybeutilizedduringinitialstageofplanning.

Domestic sewage comprises spent water from kitchen, bathroom, lavatory, *etc*. The factorswhich contribute to variations in characteristics of the domestic sewage are daily per capita use ofwater, quality of water supply and the type, condition and extent of sewerage system, and habits ofthe people. Municipal sewage, which contains both domestic and industrial wastewater, may differfrom place to place dependingupon the type of industries andindustrial establishment.Theimportantcharacteristicsofsewagearediscussed here.

3.1.1 Temperature

The observations of temperature of sewage are useful in indicating solubility of oxygen,which affects transfer capacity of aeration equipment in aerobic systems, and rate of biologicalactivity. Extremely low temperature affects adversely on the efficiency of biological treatmentsystems and on efficiency of sedimentation. In general, under Indian conditions the temperature oftheraw sewageis observedtobebetween15and350Catvariousplaces indifferentseasons.

3.1.2 ThepH

The hydrogen ion concentration expressed as pH, is a valuable parameter in the operationof biological units. The pH of the fresh sewage is slightly more than the water supplied to thecommunity. However, decomposition of organic matter may lower the pH, while the presence ofindustrial wastewater may produce extreme fluctuations. Generally the pH of raw sewage is in therange5.5to8.0.

3.1.3 ColourandOdour

Fresh domestic sewage has a slightly soapy and cloudy appearance depending upon itsconcentration. As time passes the sewage becomes stale, darkening in colour with a pronouncedsmellduetomicrobialactivity.

3.1.4 Solids

Though sewage generally containsless than 0.5 percent solids, the rest being water, stillthe nuisance caused by the solids cannot be overlooked, as these solids are highly degradable andthereforeneedproperdisposal.Thesewagesolidsmaybeclassifiedintodissolvedsolids,suspended solids and volatile suspended solids. Knowledge of the volatile or organic fraction ofsolid, which decomposes, becomes necessary, as this constitutes the load on biological treatmentunits or oxygen resources of a stream when sewage is disposed off by dilution. The estimation ofsuspended solids, both organic and inorganic, gives a general picture of the load on sedimentationand grit removal system during sewage treatment. Dissolved inorganic fraction is to be consideredwhensewageisusedforlandirrigationoranyotherreuseis planned.

3.1.5 NitrogenandPhosphorus

The principal nitrogen compounds in domestic sewage are proteins, amines, amino acids,and urea. Ammonia nitrogen in sewage results from the bacterial decomposition of these organicconstituents.Nitrogenbeinganessentialcomponentofbiologicalprotoplasm,its concentration isimportantforproperfunctioningofbiologicaltreatmentsystemsanddisposalonland.Generally, the domestic sewage contains sufficient nitrogen, to take care of the needs of thebiologicaltreatment.

For industrial wastewater if sufficient nitrogen is not present it is required to be addedexternally. Generally nitrogen content in the untreated sewage is observed to be in the range of 20to50 mg/Lmeasured asTKN.

Phosphorus is contributing to domestic sewage from food residues containing phosphorusandtheirbreakdownproducts.Theuseofincreasedquantitiesofsyntheticdetergentsaddssubstantially to the phosphorus content of sewage. Phosphorus is also an essential nutrient for thebiological processes. The concentrationof phosphorus in domestic sewageis generally adequateto support aerobic biological wastewater treatment. However, it will be matter of concerned whenthe treated effluent is to be reused. The concentration of PO4 in raw sewage is generally observedintherangeof5 to10 mg/L.

3.1.6 Chlorides

Concentration of chlorides in sewage is greater than the normal chloride content of watersupply. The chloride concentration in excess than the water supplied can be used as an indexofthe strength of the sewage. The daily contribution of chloride averages to about 8 gm per person.Based on an average sewage flow of 150 LPCD, this would result in the chloride content ofsewage being 50 mg/L higher than that of the water supplied. Any abnormal increase shouldindicate discharge of chloride bearing wastes or saline groundwater infiltration, the latter adding tothesulphates aswell,whichmayleadtoexcessivegenerationofhydrogensulphide.

3.1.7 OrganicMaterial

Organiccompoundspresentinsewageareofparticularinterestforenvironmentalengineering. A large variety of microorganisms (that may be present in the sewage or in thereceiving water body)interact with the organic material by usingit as an energy or materialsource. The utilization of the organic material bymicroorganismsis called metabolism.Theconversion of organic material by microorganism to obtain energy is called catabolism and theincorporationoforganicmaterialinthecellularmaterialis called anabolism.

To describe the metabolism of microorganisms and oxidation of organic material, it isnecessary to characterize quantitatively concentration of organic matter in different forms. In viewof the enormousvariety of organic compoundsin sewage it istotally unpractical to determinethese individually. Thus a parameter must be used that characterizes a property that all these haveincommon.Inpracticetwopropertiesofalmostallorganiccompoundscanbeused:
(1)organiccompoundcanbe oxidized;and(2)organiccompoundscontainorganiccarbon.

Inenvironmentalengineeringtherearetwostandardtestsbasedontheoxidationoforganicmaterial: 1)theBiochemicalOxygenDemand(BOD)and2)theChemical OxygenDemand(COD)tests.Inbothtests,theorganicmaterialconcentrationis measuredduringthetest.

The essential differences between the COD and the BOD tests are in the oxidant utilizedandtheoperationalconditionsimposedduringthetestsuchasbiochemicaloxidationandchemical oxidation. The other method for measuring organic material is the development of theTotal Organic Carbon (TOC) test as an alternative to quantify the concentration of the organicmaterial.

Biochemical Oxygen Demand (BOD): The BOD of the sewage is the amount of oxygen requiredforthebiochemicaldecompositionofbiodegradableorganicmatter underaerobic conditions. The oxygen consumed in the process is related to the amount of decomposable organicmatter. The general range of BOD observed for raw sewage is 100 to 400 mg/L. Values in thelowerrangearebeingcommonunderaverageIndiancities.

Chemical Oxygen Demand (COD): The COD gives the measure of the oxygen required forchemical oxidation. It does not differentiate between biological oxidisable and nonoxidisablematerial. However, the ratio of the COD to BOD does not change significantly for particular wasteand hence this test could be used conveniently for interpreting performance efficiencies of thetreatmentunits.

In general, the COD of raw sewage at various places is reported to be in the range 200 to700 mg/L. In COD test, the oxidation of organic matter is essentially complete within two hours,whereas, biochemical oxidation of organic matter takes several weeks. In case of wastewaters withalargerangeoforganiccompounds,anextradifficultyinusingBODasaquantitativeparameteris that the rate of oxidation of organic compounds depends on the nature and size of its molecules.Smaller molecules are readily available for use by bacteria, but large molecules and colloidal andsuspended matters can only be metabolized after preparatory steps of hydrolysis. It is therefore notpossibleto establish ageneralrelationshipbetweentheexperimentalfive-day BODandtheultimate BOD of a sample, *i.e.*, the oxygen consumption after several weeks. For sewage (withk=0.23 d-1 at 20^{O}C) the BOD5 is 0.68 times of ultimate BOD, and ultimate BOD is 87% of theCOD.Hence, theCOD/BODratiofor thesewageisaround1.7.

3.1.8 ToxicMetals andCompounds

Some heavy metals and compounds such as chromium, copper, cyanide, which are toxicmay findtheirway into municipal sewage throughindustrial discharges.The concentrationofthese compounds is important if the sewage is to treat by biological treatment methods or disposedoff in stream or on land. In general these compounds are within toxic limits in sanitary sewage;however,withreceiptofindustrialdischarges they maycross thelimitsinmunicipalwastewaters.

3.2 EffectofIndustrialWastes

Wastewaters from industries can form important component of sewage in both volume andcomposition. It is therefore necessary that details about nature of industries, the quantity andcharacteristics of the wastewater and their variations, which may affect the sewerage system andsewagetreatmentprocess, should becollected.

Incase,wherewastewatershighinsuspendedsolidsandBODaretobeaccepted,provision should be made in the design of the treatment plant to handle such wastes. In certaininstances, it is more economical to tackle the industrial waste at the source itself. Where, thewastewater has high or low pH, corrective measures are necessary before admitting them to thesewers or the treatment plant. Toxic metals and chemicals having adverse effects on biologicaltreatment processes, or upon fish lifein a natural water course, or render the receiving waterstream unfit as a source of water supply, should be brought down to acceptable limits at the sourceitself. Oil and grease in excessive amounts not only add considerably to the cost of treatment, butalso pose a disposal problem. The industrial wastewaters may be discharged into public sewers ifthe effluents meet the tolerance limits prescribed by the authority. If the wastewaters are to bedischarged into inland surface waters, tolerance limits set by the concerned authority should besatisfied.

3.3 EffluentDisposalandUtilization

The sewage after treatment may be disposed either into a water body such as lake, stream,river, estuary, and ocean or on to land. It may also be utilized for several purposes such as (a)industrial reuse or reclaimed sewage effluent cooling system, boiler feed, process water, *etc.*, (b)reuse in agriculture and horticulture, watering of lawns, golf courses and similar purpose, and (c)groundwaterrechargeforaugmentinggroundwaterresourcesfordownstreamusersorforpreventingsalinewaterintrusionincoastalareas.

3.4 **Status of Wastewater Generation, Collection, and Treatment in Indian Metro Cities**

Theprime cause of critical unsanitary conditions in many cities in India is due the lack of facilities tocollectwastewaterandto disposeoffaftertreatment.Dataonwastewatergeneration andcollection is less when compared to information on water supply. Hence, it is difficult to assess thetotalpollutionpotential.AspertheCPCBreportsthetotalwastewatergeneratedby23metrocities is 9,275 MLD [CPCB, 1997]. Out of this, about 58.5% is generated by the first four metrocities, *viz.* Bombay, Calcutta, Delhi and Chennai. The city of Bombay generates the maximumwastewater to the tune of 2,456 MLD and Madurai generates the least with 48 MLD [CPCB,1997]. From the available data it may be seen that the ratio of industrial to municipal wastewatervaries from 0.06% to 2%. Out of the 23 metrocities, 19 cities have sewerage coverage for morethan75%ofthe populationandthe remaining4citieshavemorethan50%coverage.Onthewhole 78% of the total metro population is provided with sewerage facility, compared to 63% in1988 [CPCB, 1997].

Out of 9275 MLD of total wastewater generated, only 31% (2,923 MLD) is treated beforeletting out and the rest *i.e.*, 6,352 MLD is disposed off untreated. Three cities have only primarytreatment facilities and thirteen have primary and secondary facilities. The municipalities disposeoff their treated or partly treated or untreated wastewater into natural drains joining rivers or lakesorusedonlandforirrigationorfoddercultivationorintotheseaorcombinationthereof.

It is found that in 12 metrocities there is some level of organized sewage farming under thecontrol of government or local body. The municipal corporations of Bhopal, Calcutta, Hyderabad,Indore, Jaipur, Madras, Nagpur, Patna, Pune, Surat, Vadodara and Varanasi have sewage farmsorganized by government / farmers and controlled by Government / Municipal Corporation /irrigation departments. The cost of sewage charge was in the range of Rs.400/ hectare / year inJaipur to Rs.75/hectare / year in Hyderabad. The average sale price of sewage works out to beRs.188/hectare/yearfor metrocities.

3.5 EconomicValueofSewage

The sewage contains nutrients, which if not optimally reused may cause eutrophication inreceiving water bodies, thus causing their premature ageing. Hence, instead of directly dischargingthe effluents into water bodies it can be used for irrigation or fodder cultivation. The economicvalue of sewage can be assessed based on itsnutrient value. Thiswill guidefor consideringsewageas asourceofincome,and tomakesewagetreatmenteconomicallyviable.

Thenutrientvalueofsewageintermsofnitrogen30mg/L,phosphate7.5mg/L,andpotassium25mg/LisprovidedbyCPCB [1997].Thetotalvalueof nutrientinsewageassuming@Rs.4220/-pertoneofnutrient(as per1996 cost),worksouttobeRs. 1018million,*i.e.*,Rs. 890.6milliontowardsnutrientsplusRs.127.4milliontowardthecostofwater.

A realistic rate for tariff towards sewage supplied for sewage farming should consider the cost ofnutrients apart from the cost of water supplied. At present the sewage is charged at average rate ofRs. 188/hectare/ annum, which is towards the cost of irrigation water only. If nutrients in thesewagearealsotobeaccountedfor, thenanadditionalcostofRs. 263/MLDor Rs. 1315 per hectare/annum should be levied for application levelsof 500 cm per hectare per annum. Hence,thetariffshouldbeleviedatRs.1503perhectare/annum(Rs.1315+188)fromcultivators [CPCB,1997].

3.6 WastewaterTreatment

Treatment and safe disposal of wastewater is necessary. This will facilitate protection ofenvironment and environmental conservation, because the wastewater collected from cities andtowns must ultimately be returned to receiving water or to the land. Once the minimum effluentquality has been specified, for maximum allowable concentrations of solids (both suspended anddissolved), organic matter, nutrients, and pathogens, the objective of the treatment is to attainreliablythesetstandards.Theroleofdesignengineeristodevelopaprocessthatwillguaranteethe technical feasibility of the treatment process, taking into consideration other factors such asconstruction and maintenance costs, the availability of construction materials and equipment, aswellasspecializedlabour.

Primary treatment alone will not produce an effluent with an acceptable residual organicmaterial concentration. Almost invariably biological methods are used in the treatment systems toeffect secondary treatment for removal of organic material. In biological treatment systems, theorganic material is metabolized by bacteria. Depending upon the requirement for the final effluentquality,tertiarytreatmentmethodsand/or pathogenremovalmayalsobeincluded.

Today majority of wastewater treatment plants use aerobic metabolism for the removal oforganic matter. The popularly used aerobic processes are the activated sludge process, oxidationditch, trickling filter, and aerated lagoons. Stabilization ponds use both the aerobic and anaerobicmechanisms.Intherecentyearsduetoincreaseinpowercostandsubsequentincreaseinoperation cost of aerobic process, more attention is being paid for the use of anaerobic treatmentsystems for the treatment of wastewater including sewage. Recently at few places the high rateanaerobicprocesssuchasUpflowAnaerobicSludgeBlanket(UASB)reactorfollowedbyoxidationpondisused forsewagetreatment.

3.6.1 CharacterizationofWastewater

The wastewater after treatment is ultimately disposed on to land or into the water body.Normally thetreatmentconsists of removal of SSandorganic matter eitherin suspendedorsoluble form, which consumes DO from the water body. The plant can be designed for 100%removal of this pollutant, but the treatment will become uneconomical. In addition, the existingwatercoursescanassimilatecertainportionofpollutionloadwithoutseriouslyaffectingtheenvironment. Thus, major portion of pollutants are removed in treatment plants and the remainingtreatment is left with natural purification process. Therefore, before proceeding with the design ofthetreatmentplant,itisessentialtodetermine

1) Thecharacteristicsoftherawwastewater,and
2) Therequireddegreeoftreatment i.e.,therequiredcharacteristicsofthetreatmentplanteffluent.

The characteristic of the wastewater differs from industry to industry and from city to cityfor domestic wastewater, depending upon the standard of living of the people and commercial andindustrial activities in the city. In absence of any data for Indian cities, the per capita SS can beconsidered as 90 to 95 gm per day and BOD as 40 to 45 gm/day. The BOD associated withsuspendedsolidsisusuallyatarateof0.25kgofBODper kgofSS.

3.6.2 CharacteristicsoftheTreatmentplanteffluent

The required quality of treatment plant effluent is dictated by the quality requirements ofthe receiving water. The quality requirements of the receiving water are established either by lawor by vigorous engineering analysis giving consideration to natural purification or selfpurificationthat occurs in the receiving water. It can either be regulated by Stream Standards looking in toassimilativecapacityofthewaterbodyordischargestandardswhichwillbeimplementeduniformly under jurisdiction of the authority without looking in to the rive water quality at specificlocation. In India the effluent standards required for domestic sewage and industrial effluent isavailableontheCentralPollutionControlBoard(CPCB)website(http://cpcb.nic.in/GeneralStandards .pdf).

3.7 ClassificationandApplicationofWastewater TreatmentMethods

The degree of treatment required can be determined by comparing the influent wastewatercharacteristics to the required effluent characteristics, adhering to the regulations. Numberofdifferenttreatmentalternatives canbedevelopedtoachievethetreatedwastewaterquality.

3.7.1 ClassificationofTreatmentMethods

Theindividualtreatmentmethods areusuallyclassifiedas:

Physical unit
operationsChemical unit
processesBiologicalunitp
rocesses.

PhysicalUnitOperations:

Treatment methods in which the application of physical forces predominates are known asphysical unit operations. Most of these methods are based on physical forces, e.g. screening,mixing,flocculation,sedimentation,flotation,andfiltration.

ChemicalUnitProcesses:

Treatment methods in which removal or conversion of contaminant is brought by additionof chemicals or by other chemical reaction are known as chemical unit processes, for example,precipitation,gastransfer, adsorption,and disinfection.

BiologicalUnitProcesses:

Treatmentmethods inwhichtheremovalofcontaminantsis broughtaboutbybiologicalactivityareknownasbiologicalunitprocesses.

Thisisprimarilyusedtoremovebiodegradable organicsubstancesfromthewastewater,eitherincolloidalordissolvedform. Inthebiologicalunitprocess,organicmatteris convertedintogases thatcanescapetotheatmosphereandintobacterialcells, whichcanberemoved bysettling. Biologicaltreatment isalsousedfornitrogenremovalandforphosphorousandsulphateremoval from the wastewater. The different treatment methods used in wastewatertreatmentplantareclassifiedinthreedifferentcategoriesas:

PrimaryTreatment:Refers tophysicalunitoperations.

SecondaryTreatment:Referstochemicaland biologicalunitprocesses.

Tertiary Treatment: Referes to any one or combination of two or all three i.e., physicalunitoperationsandchemicalorbiologicalunitprocesses,usedaftersecondarytreatmen t.

3.7.2 Elements ofplantAnalysis andDesign

Theimportantterms usedinanalysis anddesignoftreatmentplants are(CPHEEO, 1993):

FlowSheet:Itisthegraphicalrepresentationofaparticularcombinationofunitoperationsandprocesses usedintreatment.
ProcessLoadingCriteria(ordesignedcriteria):Thecriteriausedasthebasisforsizingtheindividualunito perationorprocessis knownas process loading criteria.
Solid Balance: Itisdetermined by identifying thequantitiesof solidsentering and leaving eachunitoperationor process.
Hydraulicprofile:Thisisusedtoidentifytheelevationoffreesurfaceofwastewaterasitflowsthroughvari oustreatmentunits.
Plant Layout: It is spatial arrangement of the physical facilities of the treatment plant identifiedintheflowsheet.

3.7.3 OrderofReaction

Thereactionsoccurringduringwastewatertreatmentareslowandhence,kineticconsiderations are important for design. The general equation used for relating the rate of changeofconcentration withrespecttotimecanbeexpressed as

dS/dt=K. Sn

Where, S is the concentration of the reacting substance, K is the reaction rate constant per unittime, and n denotes the order of the reaction (n = 1 for first order reaction, n = 2 for second orderreaction,and soon).

Thevalueof Kdependson theenvironmentalconditionsinthereactor,such as(a)temperature, (b) presence of toxicity, (c) presence of catalyst, (d) availability of nutrients andgrowthfactors.

Zero order reactions (n = 0) are independent of the substance concentration and hence theirrate(dS/dt)isconstant.Certaincatalyticreactionsoccurinthiswayandsometimesevenbiologicalrea ctionmayfollowzeroorder reaction.

In first order reactions, the rate of change of concentration of substance is proportional tothe concentrationof thatsubstance.Thisconcentration of the substanceandratewill diminishwithrespecttotime.Decompositionofsinglesubstrateexhibitsthetruefirstorderreaction.

Biologicalstabilizationoforganicmatterinbatchreactorisatypicalexampleofapseudofirst-order reaction. The rate of reaction is proportional to the concentration of a singleitem,organicmatterinthiscase,providedtheotherparameterscontrollingreactionsarefavourable.I fthesubstrateconcentration(organicmatter)ismaintainedconstantwithinthenarrow range (as in the case of continuous flowing, completely mixed reactors), then the rate ofreactionispracticallyconstantandthenitislikepseudo-zero-ordertypeof reaction.Somebiologicaltreatmentsystemsbehaveinthis manner.

Thereare variouscomplexprocesseswhoseoverallrateisapproximatelyfirst order in nature.

With a complex substrates (sewage or industrial wastewaters) over all reaction rate may appearlike a first order reaction, although the individual substrate among the several may exhibit the zeroorder reaction. This is because, the rate of reaction may be higher initially due to higher utilizationof easily biodegradable substrate, but rate will slower down with respect to time due to moredifficultsubstrateleftin thereactor.

3.7.4 TypesofReactorsUsed

a) ***Batch Reactor***: These reactors are operated as fill and draw type. In this the wastewater flow isnot continuous in the reactor. The reactors are operated in batch mode with fill time, reaction time,andwithdrawaltime.Forexample, BOD test,SequencingBatchReactor(SBR).The reactor content may be completely mixed to ensure that no temperature or concentration gradientexists. All the elements in the reactor, under batch mode of operation, are exposed to treatment forthe same length of time for which the substrate is held in the reactor. Hence, they are like idealplugflowreactors.

b) ***Plug-Flow (tubular flow) Reactor***: In this reactor, the fluid particles pass through the tank andare discharged in the same sequence in which they enter in the tank. The particles remain in thetank for a time equal to theoretical detention time. There is no overtaking or falling behind; nointermixing or dispersion. Longitudinal dispersion is considered as minimum and this type canoccurinhighlengthtowidthratioofthetanks.

Forexample,gritchamber, aerationtankofASP withhighlengthtowidthratio.

c) ***Continuous-flow Stirred Tank (Complete – mixed) reactor***:In this reactors, particles aredispersed immediately throughout the tank as they enter the tank. Thus, the content in the reactorare perfectly homogeneous at all points in the reactor. This can be achieved in square, circular orrectangular tank. The particles leave the tank in proportion to their statistical population. Theconcentrationoftheeffluentfromthereactoristhesameas thatinthereactor.

d) ***Arbitrary Flow***: Any degreeof partial mixing between plugflowand completely mixingcondition exists in this reactor. Each element of the incoming flow resides in the reactor fordifferent length of time. It is also called as intermixing or dispersed flow and lies between idealplug flow and ideal completely mixed reactor. This flow condition can be used in practice todescribetheflowconditionsinmostofthereactors.

e) ***Packed Bed Reactor***: They arefilled with some packing medium, such as, rock, slag, ceramicor synthetic plastic media. With respect toflow they can be anaerobic filter,when completelyfilled and no air is supplied, or aerobic (trickling filter) when flow is intermittent or submergedaerobicfilter whencompressed airissuppliedfromthebottom.

f) ***FluidizedBedReactor***: Thisreactorissimilartopackedbedexceptpackingmediumisexpanded by upward movement of fluid (or air) than resting on each other in fixed bed. Theporosity or degree of fluidization can be controlled by controlling flow rate of fluid (wastewater orair).

3.7.5 FlowPatternsofReactors

The flow pattern in the reactors depends on mixing conditions in them. This mixing in terndepends upon the shape of the reactor, energy spent per unit volume of the reactor, the size andscale of the unit, up-flow velocity of the liquid, rate of biogas generation (in an anaerobic reactors)or the rate of gas supplied (in an aerobic reactor), etc. Flow pattern affect the time of exposure totreatment and substrate distribution in the reactor. Depending upon the flow pattern the reactorscanbeclassified as:

(a) Batchreactors,
(b) Idealplugflowreactors,
(c) Idealcompletely-mixed flowreactors,
(d) Non–ideal,dispersedflowreactors,and
(e) eriesorparallelcombinationsofthereactors.

The hydraulic regime in the reactor can be defined with respect to the 'Dispersionnumber',whichcharacterizesmixingconditioninthereactor(ArceivalaandAsolekar,2007).DispersionNumber = D/UL

Where,

D=Axialorlongitudinaldispersioncoefficient,L2/t

U=Meanflowvelocityalongthereactor,L/tL=
Lengthofaxialtravelpath,L
ForidealplugflowD/UL=0,since,dispersioniszerobydefinition.D/UL≤0.2i
ndicatetheregimeapproachingplugflow conditions.
D/UL≥3.0to4.0indicatesapproachingcompletelymixedconditions.

3.8 SewageTreatmentFlowSheet

The design of process flow sheet involves selection of an appropriate combination ofvarious unitoperations and unit processes to achievea desired degreeof contaminant removal.The selection of unit operations and processes primarily depends on the characteristics of thesewage and the required level of contaminants permitted in the treated effluents. The design ofprocessflowsheetisimportant stepin overall design of wastewatertreatmentand requiresthorough understanding of the treatment units. It calls for optimization of wastewater treatmentsystem coupled with stage wise optimal design of individual operation/ process to achieve aminimalcostdesign.

The main contaminants in domestic sewage, to be removed, are biodegradable organics,Suspended Solids (SS) and pathogens, with first two having been considered as the performanceindicatorsforvarioustreatmentunits.Ingeneraltheobjectiveofthedomesticwastewatertreatment is to bring down BOD less than 30 mg/L and SS less than 30 mg/L for disposal intoinlandwater bodies.

The conventional flow sheet of sewage treatment plant consists of unit operations such asscreening, grit removal, and Primary Settling Tank (PST), followed by unit process of aerobicbiological treatment such as Activated Sludge Process (ASP)or Trickling Filter. The sludgeremoved from primary and secondary sedimentation tanks are digested anaerobically followed bydrying of anaerobically digested sludge on sand drying beds. This process flow sheet is presentedinFigure3.1.

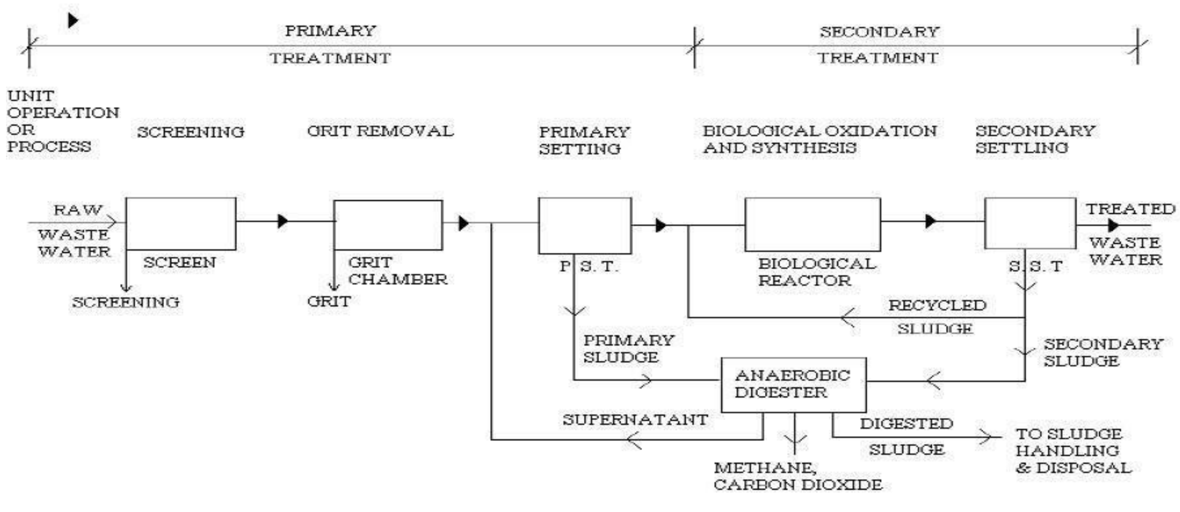
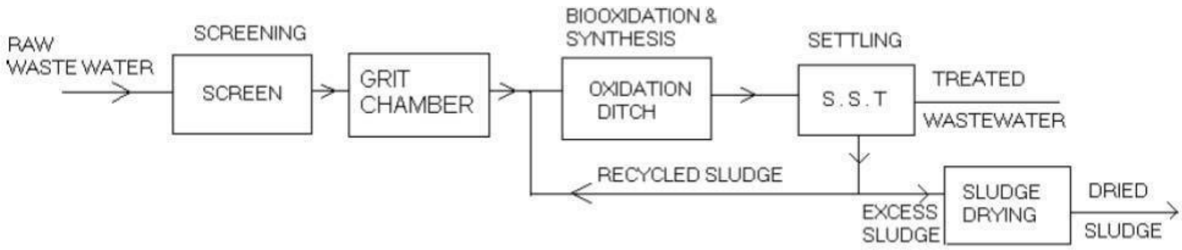
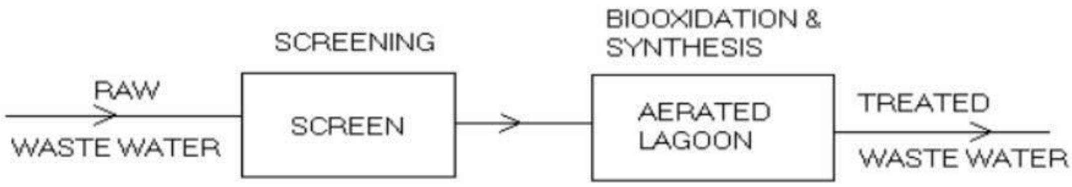


Figure3.1 Process Flow-sheetofConventionalDomesticSewageTreatmentPlant

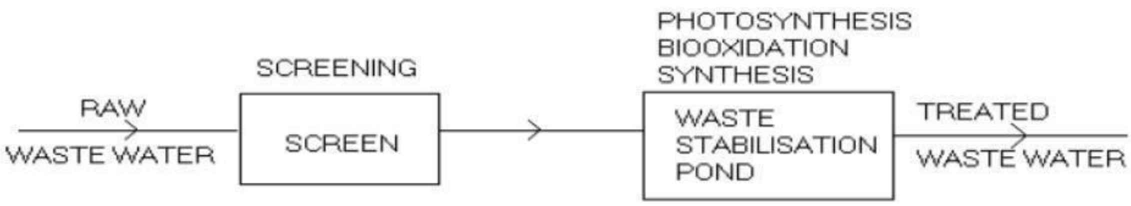
It is possible to replace the activated sludge process or trickling filter process by low costtreatmentdevices suchas oxidationditch,aeratedlagoonorwastestabilizationponds.Such treatmentdevicesobviatethe necessityofsomeoftheunit operationsandprocesseslikeprimarysedimentationandanaerobicdigestion.Someoftheprocessflow sheetsareshowninFigure3.2.



a) Process Flow sheet Incorporating Oxidation Ditch



b) Process Flow sheet Employing Aerated Lagoon



c) Process Flow sheet Employing Waste Stabilization Pond

Figure13.2 Processflowsheetusingoxidationditch,aeratedlagoon,andwastestabilizationpond

With the better understanding of microbiology and biochemistry of anaerobic treatment, it is nowfeasibletotreatdiluteorganicwastewatersuchas domesticwastewaterdirectlythroughanaerobictreatment using recently developed innovative device such as Up flow Anaerobic Sludge BlanketReactor (UASBR), Fluid–Bed Submerged Media Anaerobic Reactor (FBSMAR) and AnaerobicFilter (AF) or Static–Bed SMAR (SB-SMAR) and Anaerobic Rotating Biological Contactor (AnRBC). Though, enough field data is to be generated as yet on their performance, it is generallyreported that BOD5 removal efficiencies may range from 60-80%. Consequently, post treatmentwill generally be required to achieve the prescribed effluent standards. The process flow sheetanaerobicprocessisdepictedinFigure3.3.

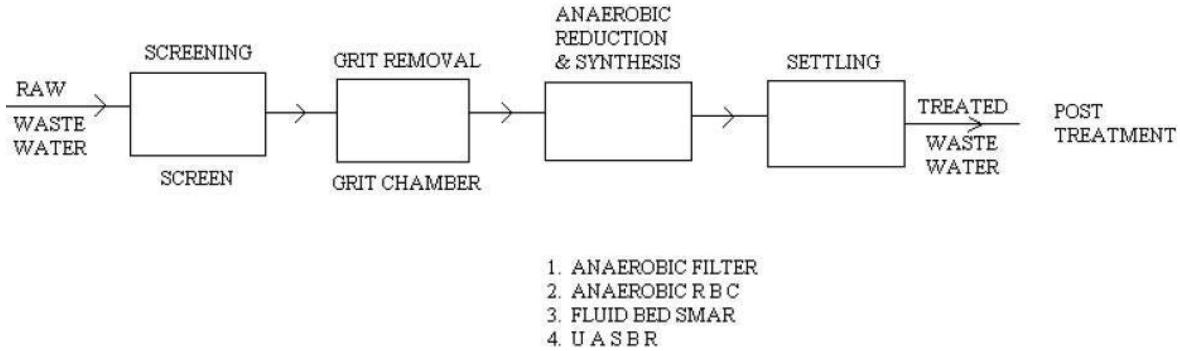


Figure3.3 Process flowsheetemployinganaerobictreatmentsystem(CPHEEO,1993)

3.9 PrimaryTreatmentUnits

Primary treatment consists solely separating the floating materials and also the heavysettable organic and inorganic solids. It also helps in removing the oils and grease from thesewage. This treatment reduces the BOD of the wastewater by about 15 to 30%. The operationsused are screening for removing floating papers, rages, cloths, etc., grit chambers or detritus tanksfor removing grit and sand, and skimming tanks for removing oils and grease; and primary settlingtank is provided for removal of residual suspended matter. The organic solids, which are separatedoutinthesedimentationtanksinprimarytreatment,areoftenstabilizedbyanaerobicdecomposition in digestion tank or incinerated. After digestion the sludge can be used as manureafterdryingonsludgedrying bedsor bysomeothermeans.

3.9.1 Bar Screens

Bar screen is a set of inclined parallel bars, fixed at a certain distance apart in a channel.These are used for removing larger particles of floating and suspended matter. The wastewaterentering the screening channel shouldhave a minimum self-clearing velocity 0.375 m/sec. Alsothe velocity should not rise to such extent as to dislodge the screenings from the bars. The slope ofthehand-cleanedscreensshouldbebetween300and450withthehorizontalandthatofmechanically cleaned screens may be between 450 and 800. The submerged area of the surface ofthe screen, including bars and opening should be about 200% of the c/s area of the extract sewerforseparatesewersand 300%for combined sewers.

Clear spacingof bars forhand cleaned bar screens may be from 25 to 50 mm and that formechanically cleaned bars may range from 15 mm to 75 mm. The width of the bars, facing theflowmaybe8mmto15mmanddepthmayvaryfrom25mmto75mm,butsizeslessthan8x25mmarenormallynotused.

3.9.2 GritChamber

Grit chambers are designed to remove grit consists of sand, gravel, cinders or other inertsolid materials that have specific gravity about 2.65, which is much greater than those of theorganic solids in the wastewater. In this chamber particles settle as individual entities and there isno significant interaction with the neighboring particles. This type of settling is referred as freesettlingorzone-Isettling.Forproperfunctioningofthegritchamber,thevelocitythroughthe grit chamber should not be allowed to change in spite of the change in flow. One of the mostsatisfactory types of automatic velocity control is achieved by providing a proportional weir at theoutlet.

The horizontal flow grit chambers should be designed in such a way that under the mostadverse conditions, all the grit particles of size 0.20 mm or more in diameter should reach the bedof the channel priorto reachingoutlet end. The length of the channel depends on the depthrequired which again depends on the settling velocity. A minimum allowance of approximatelytwice the maximum depth should be given for inlet and outlet zones. An allowance of 20-50% ofthetheoreticallengthofthechannelmayalsobegiven.

Width of grit chamber should be between 1 m to 1.5 m and depth of flow is normally keptshallow. For total depth of channel a free board of about 0.3 m and grit space about 0.25 m shouldbe provided. Forlarger plants two or more numberof grit chambers in parallel may be used. Ingritchamberstherecommendeddetentiontimeisabout30 to60 seconds.

3.9.3 SkimmingTank

The floating solid materials such as soap, vegetables, debris, fruit skins, pieces of corks,*etc.* and oil and grease are removed from the wastewater in skimming tanks. A skimming tank is achamber designed so that floating matter rises and remains on surface of the wastewater untilremoved, while the liquid flows continuously through outlet or partition below the waterlines.The detention timein skimming tank is 3 minutes. To preventheavy solids from settling at thebed, compressed air is blown through the diffusers placed in the floor of the tank. Due to compressair supply, the oily matters rise upward and are collected in the side trough, from where they areremoved. In conventional sewage treatment plant separate skimming tank is not used and thesematerials are removed by providing baffle ahead of the effluent end of the primary sedimentationtank.

3.9.4 PrimarySedimentationTank

Effluent of the grit chamber, containing mainly lightweight organic matter, is settled in theprimary sedimentation tanks. The objective of treatment by sedimentation is to remove readilysettleable solids and floating material and thus to reduce the suspended solids content when theyare used as preliminary step to biological treatment, their function is to reduce the load on thebiologicaltreatmentunits.

The primary sedimentation tanks are usually designed for a flow through velocity of 1cm/sec at average rate of flow. The detention period in the rangeof 90 to 150 minutes may beused for design. These tanks may be square, circular, or rectangular in plan with depth varyingfrom 2.3 to 5 m. The diameter of circular tanks may be up to 40 m. The width of rectangular tankmay be 10 to 25 m and the length may be up to 100 m. But to avoid water currents due to wind,length is limited up to 40 m. The slope of sludge hoppers in these tanks is generally 2:1 (vertical:horizontal). The slope of 1% is normally provided at the bed for rectangular tanks and 7.5 to 10%forcircular tanks. Thisslopeisnecessarysothatsolids mayslidetothebottombygravity.

3.10 SecondaryTreatment

Theeffluentfromprimarytreatmentistreatedfurtherforremovalofdissolvedandcolloidalorganicmatterinsecondarytreatment.Thisisgenerallyaccomplishedthroughbiochemical decomposition of organic matter, which can be carried out either under aerobic oranaerobic conditions. In these biological units, bacteria's decompose the fine organic matter, toproduce clearer effluent. The end products of aerobic decomposition are mainly carbon dioxideandbacterialcells, andthatforanaerobicprocess areCH_4,$CO_2$and bacterialcells.

Thebiologicalreactorinwhichtheorganic matterisdecomposed(oxidized)byaerobicbacteriamayconsistof:
1) Filters(tricking filters),
2) ActivatedSludgeProcess(ASP),
3) Oxidationponds,*etc.*

Thebacterialcellsseparatedoutinsecondarysettingtankswillbedisposedafterstabilizing them under aerobicor anaerobic processin a sludge digestion tank along with thesolids settledinprimarysedimentationtanks.

3.10.1 TricklingFilter

Trickling filters can be used for complete treatment for domestic waste and as roughingfilter for strong industrial waste prior to activated sludge process. The primary sedimentation tankis provided prior to tricklingfilter so thatthe settleable solidsin the sewage may notclog thefilter. The trickling filter is followed by secondary settling tank for removal of settleablebiosolidsproducedinfiltrationprocess.

As the wastewater trickles through the filter media (consisting rocks of 40 to 100 mm sizeor plastic media), a biological slime consisting of aerobic bacteria and other biota builds up aroundthe media surface. Organic material in the sewage is absorbed on the biological slime, where theyarepartlydegraded bythebiota, thusincreasing thethickness ofthebiofilm.

Eventually there is a scouringof the biofilm andfresh biofilm begins togrowon themedia. Thisphenomenon of detachmentof the biofilmis called sloughingof thefilter. Thetrickling filters are classified as low rate and high rate depending on the organic and hydraulicloadings. Low rate filters are designed forhydraulic loading of 1 to 4 m3/m2.d and organicloadings as 80 to 320 g BOD/m3.d. The high rate trickling filters are designed for hydraulicloading of 10 to 30 m3/m2.d (including recirculation) and organic loading of 500 to 1000 gBOD/m3.d (excluding recirculation). Generally recirculation is not adopted in low rate filter andrecirculation ratio of 0.5 to 3.0 or higher is used in case of high rate trickling filters. The depth ofmedia varies from 1.0 to 1.8 m for high rate filters and 2.0 to 3.0 m for low rate filters. The bed oftricklingfilteris provided with slope 1in 100 to 1in 50.The under drainage system consistsof'V' shaped orhalf round channels, castin concretefloor duringitsconstruction. Revolvingdistributors are provided at top with two or four horizontal arms of the pipe having perforations orholes. These rotating arms remain 15 to 25 cm above the top surface of the media. The distributionarmsarerotatedbytheelectricmotororbybackreactiononthearmsbythewastewater,atabout2 rpm. Theheadof30 to80cmofwastewateris requiredtorotatethearms.

3.10.2 ActivatedSludgeProcess

It is aerobic biological treatment system. The settled wastewater is aerated in an aerationtank for a period of few hours. During the aeration, the microorganisms in the aeration tankstabilize the organic matter. In this process part of the organic matter is synthesized into new cellsand part is oxidized to derive energy. The synthesis reaction followed by subsequent separation oftheresultingbiologicalmassandtheoxidationreactionisthemainmechanismofBODremovalintheactivated sludgeprocess.

The biomass generated in the aeration tank is generally flocculent and it is separated fromthe aerated wastewater in a secondary settling tank and is recycled partially to the aeration tank.The mixture of recycled sludge and wastewaterin the aeration tank is referred as mixedliquor.Therecyclingofsludgehelpsintheinitialbuiltupofahighconcentrationofactivemicroorganisminthemixedliquor,whichaccelerates BOD removal.Oncetherequired concentrationof microorganismin the mixedliquorhasbeen reacheditsfurtherincreaseisprevented by the regulating quantity of sludge recycled and wasting the excess sludge from thesystem.

Aeration units are main units of activated sludge process, the main aim of which is tosupply oxygen to the wastewater to keep the reactor content aerobic and to mix up the returnsludge with wastewater thoroughly. The usual practice is to keep the detention period between 6 to8 hours for treatment of sewage or similar industrial wastewater. The volume of aeration tank isalso decided by considering the return sludge, whichis about 25 to 50%of the wastewatervolume.

Normally liquid depth provided should be between 3 and 4.5 m. A free board of 0.3 to 0.6m is also provided. The mode of air supply in aeration tank can be either diffused air aeration, bysupplementing compressed air from tank bottom, or by mechanical aerators provided at surface orby both diffused aeration and mechanical aerators. Depending on flow regime the activated sludgeprocess can be classified as conventional (plugflow) and completely mixed activated sludgeprocess. The modification of activated sludge process such as extended aeration is popularly usedfor treatment of wastewaters. The extended aeration is design for higher hydraulic retention time(18h) andlowF/Mratio(0.05 to0.15kg COD/kgVSS.d).

3.10.3 SecondarySettlingTank(SST)

Design of secondary settling is somewhat different than that of the primary settling tanks.In the secondary settling tank the function served is clarification as well as thickening of thesludge. This type of settling which takes place in secondary settling tank is refereed as zonesettlingfollowedbycompression.TheSSTis designedfordetentionperiodof1.5to2.5h.

The depth of the tank can be between 2.5 and 4.5 m. The area of the tank is to worked outon the basis of surface overflow rate, overflow rate for SST of trickling filter should be 15-25m3/m2.d and for SST of ASP 15-35 m3/m2.d at average flow. The length of effluent weir shouldbesuchthattheweirloading rateisless than185 m3/m.d.

3.10.4 OxidationPonds

Oxidation ponds are the stabilization ponds, which received partially treated sewage. It isan earthen pond dug into the ground with shallow depth. The pond should be at least 1.0 m deep todiscouragegrowthofaquaticweedsandshouldnotexceed1.8m.Thedetentiontimeinthepondis usually 1 to 4 weeks depending upon sunlight and temperature. Better efficiency of treatment isobtained if several ponds are placed in series so that the sewage flows progressively from one toanotherunituntilitisfinallydischarged.

The surface area of the pond may be worked out by assuming a suitable value of organicloading which may rangefrom 150–300kg/ha/din hot tropical countrieslike India. Each unitmayhaveanarearanging between0.5 to1.0hectare.

The length of the tank may be kept about twice the width. A free board of about 1 m mayalso be provided above a capacity corresponding to 20-30 days of detention period. Properlyoperated ponds may be as effective as trickling filter in reducing the BOD of sewage. The BODremovalefficiencyofpondisup to90% and Coliformremovalefficiencyofpondisup to99%.

3.10.5 SludgeTreatment

Sludge drying beds are commonly used in small wastewater treatment plants to dewater the sludgeprior to final disposal. Two mechanisms are involved in the process, such as filtration of waterthrough the sand, and evaporation of water from sludge surface. The filtered water is returned totheplantfortreatment. Theprocessis wellsuitedtosludge,whichhaveunder gone proper aerobic or anaerobic digestion. Sludge from the conventional activated sludge, contactedstabilization, trickling filter, and rotating biological contactor processes usually contain a largeamount of volatile solid, which tendto unpleasantodour problem. Therefore thismethodisgenerallynotsuitableforhandlingthissludgewithoutpriorstabilization,anddigestionofsludgeis essentialprior toapplicationofsludgeonsludgedrying beds.

A typical sludge drying bed consist of 15 to 30 cm of coarse sand layer underlain byapproximately 20 to 45 cm of grade gravel ranging in size from 0.6 to 4 cm. Open jointed tubes of10 to 15 cm diameter spaced at 2.5 to 6 cm are laid in the gravel to provide drainage for liquidpassing through the bed. Sludge is applied to the drying bed in layer of 20 to 30 cm, dependinguponlocalclimaticconditionsthesludgeisallowedtodryfor twotofour weeks.

Enclosing drying beds with glass can improve the performance of the dewatering process,particularly in cold or wet climates. For an enclosed bed the area required for a bed may getreducedtotwothird ascompared toarearequiredforopenbeds.

3.11 TertiaryTreatment

This treatment is sometimes called as the final or advanced treatment and consists ofremoving the organic matter left after secondary treatment, removal of nutrients from sewage, andparticularly to kill the pathogenic bacteria. Disinfection is normally carried out by chlorination forsafe disposal of treated sewage in water body which is likely to be used at downstream for watersupplies. However, for other reuses tertiary treatment is required for further removal of organicmatter,suspendedsolids,nutrientsandtotaldissolved solids as pertheneeds.

Thesewagetreatmentisgenerallyconfineduptosecondarytreatmentonly.Variousphysicalchemicalandbiologicalprocessesareavailablefortreatment,dependingupontheparticular requirements. The choice of treatment methods depends on several factors, including thedisposalfacilitiesavailable.Actually,thedistinctionbetweenprimary,secondary&tertiarytreatmentisratherarbitrary,sincemanymoderntreatmentmethodsincorporatephysical,chemical,and biologicalprocesses inthesameoperations.

Thesecondarytreatmentcanbeachievedbyaerobicprocessoranaerobicprocess.Conventionally the aerobic process i.e. activated sludge process is used for sewage treatment. As alow cost treatment option, oxidation pond can also be used for sewage treatment. With the adventof the energy crises, the use of anaerobic processare being taken into consideration in greaterdepthasasubstitutesforthetraditionalenergydependentactivatedprocessorlargeareademanding oxidation ponds. The application of anaerobic process for wastewater treatment isattractiveonly if largevolumes of wastewater can be forced through the systemin a relativelyshort period of time. This will give low hydraulic retention time and therefore anaerobic reactorbecomes spaceefficient.

Today majority of wastewater treatment plants use aerobic metabolism for the removal oforganic matter. The most well known aerobic processes are the activated sludge process, oxidationditch, oxidation pond, trickling filter, and aerated lagoons. Stabilization ponds use both the aerobicand anaerobic mechanisms. In the recent years due to increase in power cost and subsequentincrease in operation cost of aerobic process, more attention is being paid for the use of anaerobictreatment systems for the treatment of wastewater including sewage. At few places the high rateanaerobicprocess suchas UASBreactoris successfullyusedfortreatmentofsewage.

3.12 EffluentQualityRequirement

For disposal of treated effluentin the waterbody orreuseforirrigation theeffluentstandards are defined by Central Pollution Control Board (www.cpcb.nic.in) . For discharge oftreated sewage in water body the standard for BOD and SS is 30 mg/L and for application on landforirrigationitis100mg/L.Fordetailsaboutotherparameters refertotheCPCBwebsite.

3.13 Screens

Theprimarytreatmentincorporatesunitoperationsforremovaloffloatingandsuspended solids from the wastewater. They are also referred as the physical unit operations.The unit operations used are screening for removing floating papers, rages, cloths, plastics,cansstoppers,labels,etc.;gritchambersordetritustanksforremovinggritandsand;skimmingtanksforremovingoilsandgrease;andprimary settlingtankforremoval ofresidualsettleablesuspendedmatter.

Screen is the first unit operation in wastewater treatment plant. This is used to removelarger particles of floating and suspended matter by coarse screening. This is accomplished bya set of inclined parallel bars, fixed at certain distance apart in a channel. The screen can be ofcircular orrectangular opening.Thescreencomposedofparallelbarsorrodsiscalledarack.

The screens are used to protect pumps, valves, pipelines, and other appurtenances fromdamage or clogging by rags and large objects. Industrial wastewater treatment plant may ormay not need the screens. However, when packing of the product and cleaning of packingbottles/containersiscarriedout,itisnecessarytoprovidescreensevenforindustrialwastewater treatment plant to separate labels, stopper, cardboard, and other packing materials.The cross section of the screen chamber is always greater (about 200 to 300 %) than theincoming sewer. The length of this channel should be sufficiently long to prevent eddiesaroundthe screen.The schematic diagramofthe screenisshowninthe Figure

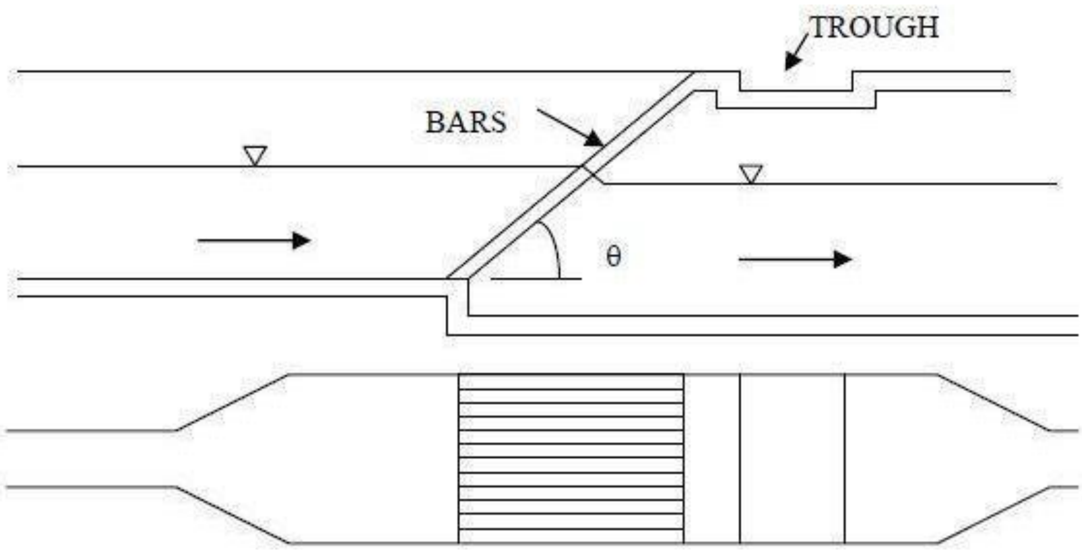


Figure:BarScreen

3.13.1 TypesofScreens

Screens can be broadly classified depending upon the opening size provided as coarsescreen (bar screens) and fine screens. Based on the cleaning operation they are classified asmanuallycleanedscreensormechanicallycleanedscreens.Duetoneedofmoreandmorecompacttreat mentfacilitiesmanyadvancementinthescreendesignarecomingup.

3.13.1.1 CoarseScreen

It is used primarily as protective device and hence used as first treatment unit. Commontype of these screens are bar racks (or bar screen), coarse woven-wire screens, and comminutors.Bar screens are used ahead of the pumps and grit removal facility. This screen can be manuallycleaned or mechanically cleaned. Manually cleaned screens are used in small treatment plants.Clearspacing betweenthebarsinthesescreensmaybeintherangeof15 mmto40 mm.

3.13.1.2 GrinderorComminutor

It is used in conjunction with coarse screens to grind or cut the screenings. They utilizecutting teeth (or shredding device) on a rotating or oscillating drum that passes through stationarycombs (or disks). Object of large size are shredded when it will pass through the thin opening ofsize0.6 to1.0 cm.Provisionofbyepass tothis deviceshouldalwaysbemade.

3.13.1.3 FineScreen

Fine screens are mechanically cleaned screens using perforated plates, woven wire cloths,or very closely spaced bars with clear openings of less than 20 mm, less than 6 mm typical.Commonly these are available in the opening size ranging from 0.035 to 6 mm. Fine screens areused for pretreatment of industrial wastewaters and are not suitable for sewage due to cloggingproblems, but can be used after coarse screening. Fine screens are also used to remove solids fromprimary effluent to reduce clogging problem of trickling filters. Various types of microscreenshave been developed that are used to upgrade effluent quality from secondary treatmentplant.Fine screen can be fixed or static wedge-wire type, drum type, step type and centrifugal screens.Fixed or static screens are permanently set in vertical, inclined, or horizontal position and must becleaned by rakes, teeth or brushes. Movable screens are cleaned continuously while in operation.Centrifugalscreens utilizetherotatingscreensthatseparateeffluentandsolids areconcentrated.

3.13.1.4 TypesofMediumandFineScreens

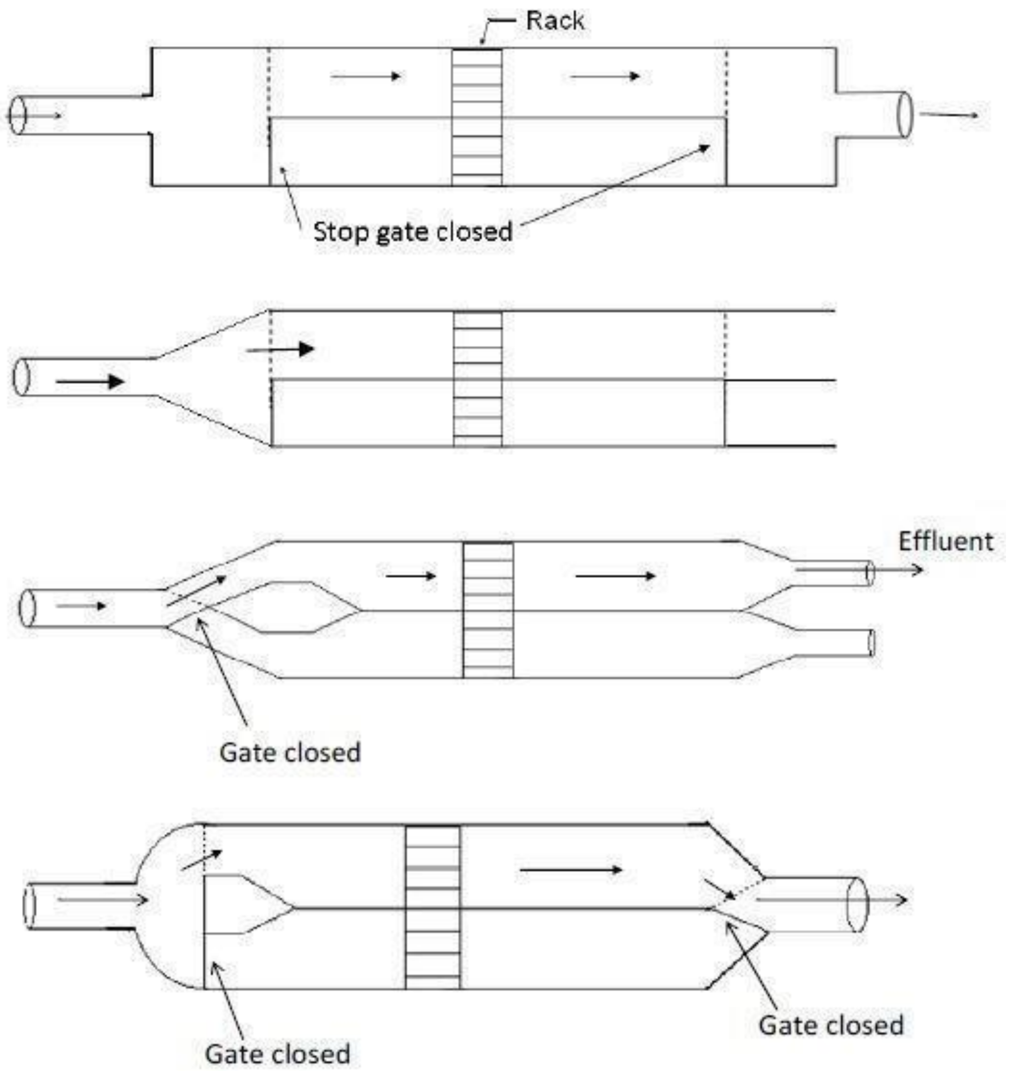
Inclined (fixed): These are flat, cage, or disk type screens meant for removal of smaller particles.These are provided with opening of 0.25 to 2.5 mm. They are used for primary treatment ofindustrialeffluents.

Band: It consists of an endless perforated band that passes over upper and lower sprocket. Brushesare installed to remove the material retained over the screen. Water jet can be used to flush thedebris. Opening size of 0.8 to 2.5 mm is provided in this screen. They are used for primarytreatmentofindustrialeffluents.

DrumScreenorstrainer:Itconsistsofrotatingcylinderthathasscreencoveringthecircumferential area of the drum. The liquid enters the drum axially and moves radially out. Thesolids deposited are removed by a jet of water from the top and discharged into a trough. Themicro-strainers have very fine size screens and are used to polish secondary effluent or removealgaefromtheeffluentofstabilizationponds. Openingsizeof1to5mmand0.25to2.5mmis used for primary treatment and opening size of 6 to 40 μm is used for polishing treatment ofsecondaryeffluents.

3.13.2 ScreenChamber

It consists of rectangular channel. Floor of the channel is normally 7 to 15 cm lower thanthe invert of the incoming sewer. Bed of the channel may be flat or made with desired slope. Thischannel isdesign to avoiddepositionof grit andothermaterialsin toit.Sufficient straightapproach length should be provided to assure uniform distribution of screenings over the entirescreenarea.Atleasttwobarracks,eachdesignedtocarrypeakflow,mustbeprovided.Arrangemento fstoppingtheflowanddrainingthechannelshouldbemadeforroutinemaintenance.Theentrancestructure shouldhaveasmooth transitionordivergenceto avoidexcessive head loss and deposition of solids (Figure 14.2). Effluent structure should be havinguniform convergence. The effluent from the individual rack may be combined or kept separate asnecessary.



FigureDoublechamberbarscreenandinfluentandeffluentarrangement

3.13.3 RequirementsandSpecificationsforDesignofBarScreen

1. The velocity of flow ahead of and through a screen varies materially and affects its operation.Lower the velocity through the screen, the greater is the amount of screening that would beremoved. However, at lower velocity greater amount of solids would be deposited at the bottom ofthescreenchannel.

2. Approachvelocityofwastewaterinthescreeningchannelshallnotfallbelowaselfcleansingvelocity of0.42m/secorrisetoamagnitudeatwhichscreeningswillbedislodgedfromthebarsThesuggestedappr oachvelocityis 0.6to0.75m/secfor thegritbearing wastewaters.

Accordinglythebedslopeofthechannelshouldbeadjustedtodevelopthis velocity.

The suggested maximum velocity through the screen is 0.3 m/sec at average flow for handcleanedbarscreensand0.75m/secatthenormalmaximumflowformechanicallycleanedbar screen (Rao and Dutta, 2007). Velocity of 0.6 to 1.2 m/sec through the screen openingforthepeakflowgivessatisfactoryresult.

3. Headlossesduetoinstallationofscreensmustbecontrolledsothatbackwaterwillnotcausethe entrant sewer to operate under pressure. Head loss through a bar rack can be calculated byusingKirchmer'sequation:

$$h=\beta(W/b)^{4/3} h_v \sin\theta \qquad (1)$$

where, h=head loss,m

β=Barshapefactor

=2.42forsharpedgerectangularbars

=1.83forrectangularbarswithsemicircularupstream

=1.79forcircularbars

=1.67forrectangularbarswithbothu/sandd/sfacesassemicircular.

W = Width of bars facing the flow,

mb=Clearspacingbetweenthebars,m

h_v=Velocityheadofflow approachingthebars,m

$= V^2/2g$

V=geometricmeanoftheapproachvelocity,m/secθ=A ngleofinclinationofthebars withhorizontal.

Usually accepted practice is to provide loss of head of 0.15 m but the maximum loss ofhead with the clogged hand cleaned screen should not exceed 0.3 m. For mechanically cleanedscreen,theheadlossis specifiedbythemanufacturer,anditcanbebetween150to600mm.

Theheadlossthroughthecleanedorpartiallycloggedflatbarscreencanalsobecalculatedusingfoll owingformula:

$$h= 0.0729 (V^2 – v^2) \qquad (2)$$

Where,h=lossofhead,m

V=velocitythroughthescreen,m/sec

v=velocitybeforethescreen,m/sec

The headlossthroughthefinescreencanbecalculatedas:

$$h=(1/(2g.C_d))(Q/A)^2 \qquad (3)$$

Where, g = gravity acceleration (m/sec2); C_d is coefficient of discharge = 0.6 for clean rack;Qis dischargethroughscreen(m3/sec);andA iseffectiveopensubmergedarea(m2).

4. The slope of the hand cleaned screen should be in between 30 to 60^o with horizontal. Themechanically cleaned bar screens are generally erected almost vertical; however the angle with thehorizontalcanbeintherange45 to85^o.
5. The submerged area of the surface of the screen, including bars and opening should be about200% of the cross sectional area of the incoming sewer for separate system, and 300% for thecombinedsystem.
6. The clear spacing between the bars may be in the range of 15 mm to 75 mm in case ofmechanically cleaned bar screen. However, for the manually cleaned bar screen the clear spacingused is in the range 25 mm to 50 mm. Bar Screens with opening between 75 to 150 mm are usedahead of raw sewage pumping. For industrial wastewater treatment the spacing between the barscouldbebetween6 mmand 20 mm.
7. Thewidthofbarsfacing theflowmayvaryfrom5 mmto15 mm,and thedepthmayvaryfrom25mmto75 mm. Generallybarswithsizeless than5 mmx 25 mmarenotused. Thesebars areweldedtogetherwithplatefromdownstreamsidetoavoiddeformation.

3.13.4 QuantitiesofScreening

The quantity of screening varies depending on the type of rack or screen used as well assewer system (combined or separate) and geographic location. Quantity of screening removed bybar screen is 0.0035 to 0.0375 m^3/ 1000 m^3 of wastewater treated (Typical value = 0.015 m^3/1000m^3ofwastewater)(Metcalf&Eddy,2003).Incombinedsystem,thequantityofscreeningincreases during storm and can be as high as 0.225 m^3/1000 m^3 of wastewater. For industrialwastewaters quantity of the screening depends on the characteristics of the wastewater beingtreated.

3.13.5 DisposalofScreenings

Screening can be discharged to grinders or disintegrator pumps, where they are ground andreturned to the wastewater. Screenings can be disposed off along with municipal solid waste onsanitarylandfill.Inlargesewagetreatmentplant,screeningscanbeincinerated.Forsmallwastewatertreatmentplant, screeningsmaybedisposed offbyburialontheplantsite.

Example:1

Designabarscreenchamberforaveragesewage flow20MLD,minimumsewageflowof12 MLDandmaximumflowof30 MLD.

Solution:

1. Average flow=20MLD
=0.231m3/Sec
MaximumFlow=30 MLD
=0.347m3/Sec
Minimumflow =12MLD
=0.139m3/Sec
2. Assumemanualcleaningandangleofinclinationofbars withhorizontalas 30^o.
Assume size of bars 9 mm x 50 mm, 9 mm facing the flow. A clear spacing of 30 mm betweenthebarsisprovided.
3. Assumevelocityofflownormaltoscreenas0.3m/secataverageflow.
4. Netsubmergedareaofthescreenopeningrequired
=

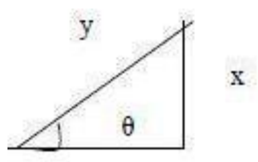
$$\frac{0.231\ m^3/Sec}{0.3\ m/sec} = 0.77\ m^2$$

Assumevelocityofflownormaltothescreenas0.75m/secatmaximumflow,hencenetsubmerged areaofscreenopening

$$\frac{0.347\ m^3/Sec}{0.75\ m/sec} = 0.46\ m^2$$

Providenetsubmergedarea=0.77m2
5. Grosssubmergedareaofthescreen
When ‘n’ numbers of bars are used the ratio of opening to the gross width will be[(n+1)30]/[(n+1)30 +9x n]≈0.77(for20 to30numberofbars)
Thereforegrosssubmergedareaofthescreen0.77 /0.77 = 1 m2
6. Thesubmergedverticalcross sectionalareaofthescreen= 1.0x Sin30= 0.5m2 Thisis equaltoc/sareaofscreenchamber,thereforevelocityofflowinscreenchamber

=0.231 /0.5= 0.462 m/sec
Thisvelocityisgreaterthantheselfcleansingvelocityof0.42m/sec
7. Provide30numbersofbars.Thegross widthofthescreenchamberwillbe:
= 30 x0.009 +31x 0.03= 1.2 m
Therefore, liquid depth at average flow = 0.5 / 1.2 = 0.416 mProvidefreeboard of0.3m
Hence,totalsdepthof thescreen= 0.416 +0.3 = 0.716 m, say0.75 mThus,thesizeofthechannel= 1.2 m(width) x0.75m(depth)
8. Calculationforbedslope:
R= A/P= (0.416 x 1.2) /(2 x0.416 + 1.2)
= 0.246 m
Now, V = (1/n) $R^{2/3}$
$S^{1/2}S^{1/2}$= V.n/$R^{2/3}$
= 0.462 x 0.013
/$(0.246)^{2/3}S^{1/2}$=0.0153
Thereforebedslopeisnearly1in4272m
9. Headlossthroughthescreen,h,whenscreenisnotclogged.h= $\beta(W/b)^{4/3}$hvSinθ
=2.42$(9/30)^{4/3}$[$(0.462)^2$/(2x 9.81)]Sin 30 = 2.65 x10^{-3}m=0.00265 m=2.65 mm
Forhalfcloggedscreen,theheadlosscanbeworkedoutusingopeningwidthashalf
Thus,b=30/2=15mm
And h = 6.67 x 10^{-3} m = 6.67 mm < 150 mmHowever,provide150mmdropofafterscreen.



Sin 30 = x/Y

If this head loss is very excessive, this can be reduced by providingbarswithroundededgesatupstream,orbyreducingwidthofbarsto6to 8mm, or byslightreductioninvelocity.

Except for the change in shape of bars in other cases the channel dimensions will change. Forminimum flow and maximum flow, the depth of flow can be worked out using Manning's formulausing known discharge, and check for velocity under both these cases, as self cleansing and non-scouring,respectively,andalsodepthofflow atmaximumdischarge.

Exercise: Determineheadloss through a bar screen when itis 50% clogged. The approachvelocity of wastewater in the channel is 0.6 m/sec, velocity of flow through the clear rack is 0.8m/sec.Clearopeningareainthescreenis0.2m2.Considerflowcoefficientforcloggedbarrackas0.6.

Answer:

Q5:Headloss throughabarscreenwhenitis 50%clogged=0.187m

3.14 GritChamber

Grit chamber is the second unit operation used in primary treatment of wastewater and it isintendedtoremovesuspendedinorganicparticlessuchassandy andgrittymatterfromthewastewater.Thisisusuallylimitedtomunicipalwastewaterandgenerallynotrequiredforindustrial effluent treatment plant, except some industrial wastewaters which may have grit. Thegrit chamber is used to remove grit, consisting of sand, gravel, cinder, or other heavy solidsmaterials that have specific gravity much higher than those of the organic solids in wastewater.Grit chambers are provided to protect moving mechanical equipment from abrasion and abnormalwear; avoid deposition in pipelines, channels, and conduits; and to reduce frequency of digestercleaning. Separate removal of suspended inorganic solids in grit chamber and suspended organicsolids in primary sedimentation tank is necessary due to different nature and mode of disposal ofthese solids. Grit can be disposed off after washing, to remove higher size organic matter settledalong with grit particles; whereas, the suspended solids settled in primary sedimentation tank,beingorganicmatter, requiresfurther treatmentbeforedisposal.

3.14.1 HorizontalVelocityinFlowThoughGritChamber

The settling of grit particles in the chamber is assumed as particles settling as individualentities and referred as Type – I settling. The grit chamber is divided in four compartments a inletzone,outletzone, settling zoneand sludgezone(Figure)

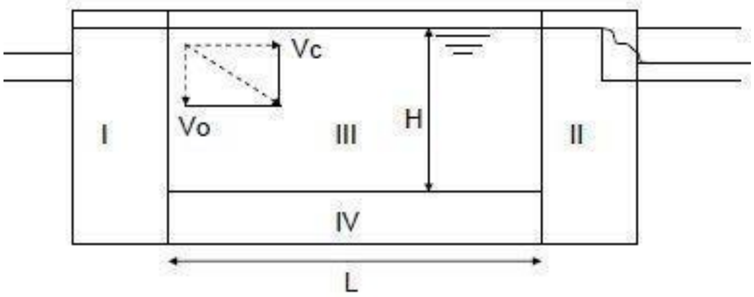


Figure15.1Compartmentsofgrit chamber

Zone–I:Inletzone:Thiszonedistributestheincomingwastewateruniformlytoentirecrosssectionofthegritchamber.

Zone–II:Outletzone:This zonecollectsthewastewateraftergritremoval.Zone–III:Settlingzone:Inthis zonesettlingofgritmaterialoccurs.

Zone–IV:Sludgezone:Thisis azonewheresettledgritaccumulates.L–Lengthofthesettling zone

H–Depthofthesettlingzone

v–Horizontal velocityofwastewater
Vo – Settling velocity of the smallest particle intended to be removed in grit chamber.Now,ifVsisthesettlingvelocityofanyparticle, then
For Vs □Vo these particles will be totally removed,ForVs< Vo,
theseparticleswillbepartiallyremoved,
Where, Vo is settling velocity of the smallest particle intended to be removed. The smallestparticle expected to be removed in the grit chamber has size 0.2 mm and sometimes in practiceevensizeofthesmallestparticleis consideredas 0.15mm.Theterminalvelocitywithwhichthissmallest particle will settle is considered as Vo. This velocity can be expressed as flow ordischarge per unit surface area of the tank, and is usually called as ‘surface overflow rate’ or‘surfacesettlingvelocity’.Nowfor100percentremovaloftheparticles withsettlingvelocityVs □ Vo,wehave
Detentiontime= L/v=H/VoOr L/H =v/Vo (1)
Topreventscouringofalreadydepositedparticles themagnitudeof‘v’shouldnotexceedcriticalhorizontalvelocityVc, and theaboveequationbecomesL/H= Vc/Vo

Thecriticalvelocity, Vc, canbegiven bythefollowingequation(Raoand Dutta, 2007):

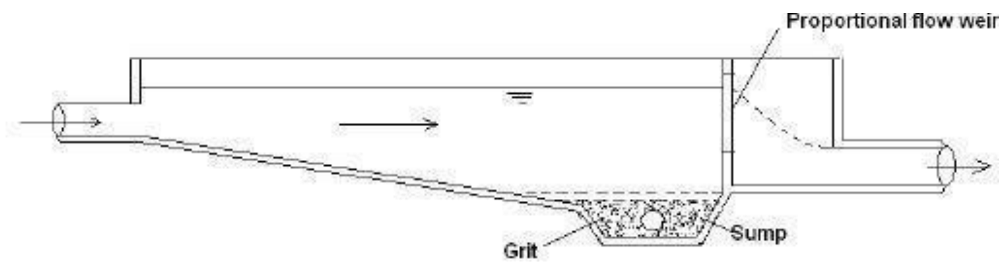
$$Vc = \sqrt{\left[\frac{8\beta}{f} g(S-1)D\right]} \qquad (2)$$

where,β=constant
=0.04forunigranularsand
=0.06fornon-uniformstickymaterial
f=Darcy–Weisbachfrictionfactor=0.03forgrittymatterg= Gravitationalacceleration,
S =Specificgravityoftheparticletoberemoved(2.65 forsand),andD = Diameteroftheparticle,m

Thegrit chambers are designed to removethe smallest particleof size 0.2 mm withspecificgravity around2.65.Fortheseparticles,usingaboveexpression thecriticalvelocitycomes outtobeVc= 0.228 m/sec.

3.14.3HorizontalFlowRectangularGritChamber

A long narrow channel is used in this type of grit chamber (Figure 15.2). The wastewatermoves through this channel in more or less plug flow condition with minimal mixing to supportsettlingof the particles. Higherlength to width ratio of the channel is used to minimize mixing.For this purpose a minimum allowance of approximately twice the maximum depth or 20 to 50%of the theoretical length of the channel should be given for inlet and outlet zones. The width of thischannel is kept between 1 and 1.5 m and the depth of flow is normally kept shallow. A free boardof minimum 0.3 m and grit space of about 0.25 m is provided. For large sewage treatment plant,two or more number of grit chambers are generally provided in parallel. The detention time of 30to60 secondsisrecommendedfor thegritchamber.

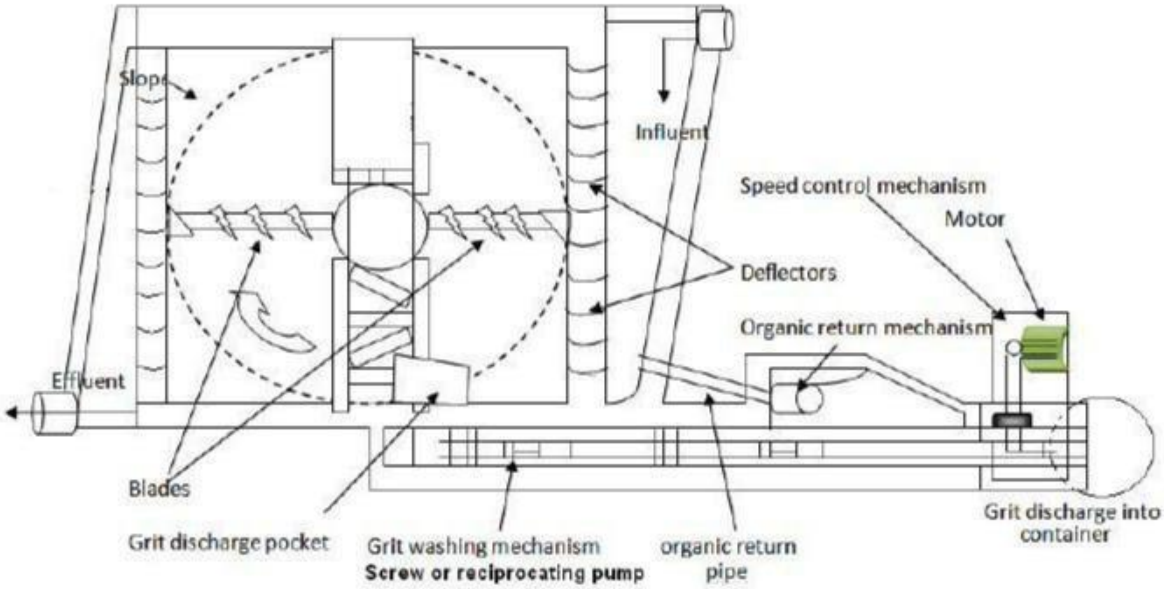


FigureHorizontalflowgritchamber

Example:1
Designagritchamberforpopulation50000withwaterconsumptionof135LPCD.
Solution
Averagequantityofsewage,considering sewagegeneration80%ofwater supply,is
=135x50000x0.8=5400m3/day=0.0625m3/secMaximumfl
ow =2.5 xaverageflow
=0.0625 x 2.5 =0.156 m3/sec
Keepingthehorizontalvelocityas0.2m/sec(<0.228m/sec)anddetentiontimeperiodas oneminute.
Lengthofthegritchamber =velocityxdetentiontime
= 0.2 x60 =12.0m
Volumeofthegritchamber=Dischargexdetentiontime
= 0.156 x 60 =9.36 m3
Cross sectionareaof flow 'A'=Volume/Length=9.36/12=
0.777m2Providewidthofthechamber = 1.0m, hencedepth=0.777m
Provide25%additionallengthtoaccommodateinletandoutletzones.Henc
e,thelengthofthegritchamber =12 x1.25 =15.0 m
Provide0.3mfreeboardand0.25mgritaccumulationzonedepth,hencetotaldepth
=0.777 +0.3 + 0.25 =1.33 m
andwidth=1.0 m

3.14.6 SquareGritChamber

Thehorizontalflowrectangulargritchamberfacestheproblemofsedimentationoforganic matter along with grit particles, requiring external washingof the grit before disposal.This problem can be minimized by providing square shape of the grit chamber rather than longrectangularchannel.Also,this shapewillfacilitatecompactdesignofsewagetreatmentplant.
Hencethesedays'squaregritchambersareused.Insquaregritchamber,theflowdistributionmay not be uniform due to non-ideal plug flow conditions, and hence continuous removal of grit isgenerally considered essential. These are designed based on overflow rates that are dependent onthe particle size and temperature of wastewater. Minimum two number of grit chambers should beused to facilitate maintenance of the raking mechanism, whenever required. The grit deposited atthe bottom is raked by rotating mechanism to a sump at the side of the tank, from which it ismoved up by an inclined reciprocating rake or screw pump mechanism (Figure 15.5). Whilepassing up the incline conveyer, organic solids are separated from grit and flow back into thebasin. Thus, cleaned washed grit is obtained, compared to the grit obtained from separate gritwashers.



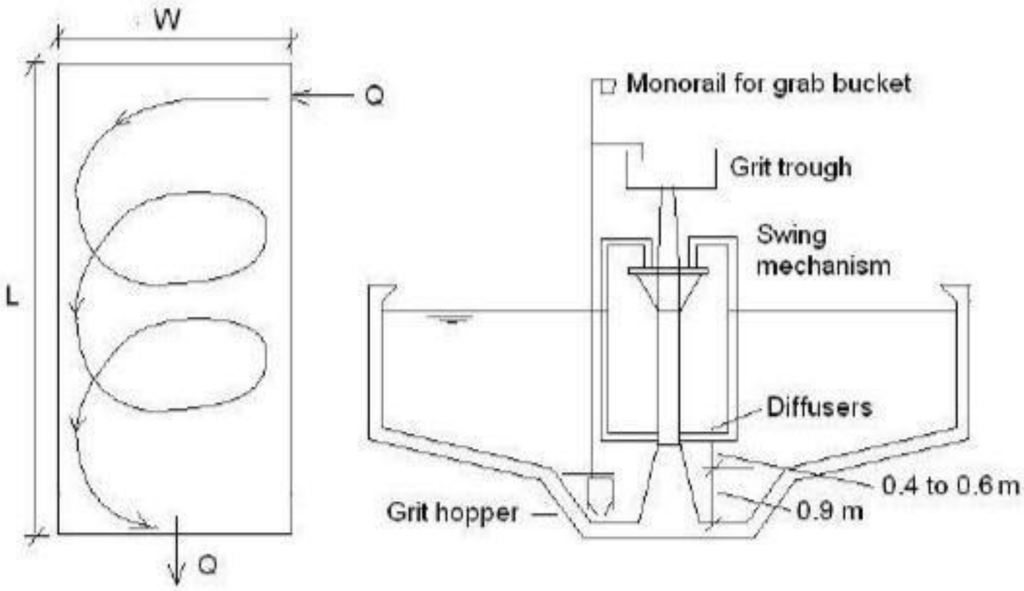
FigureSquaregritchamber

3.14.7 AeratedGritChamber

Excessive wear of grit handling equipment and necessity of separate grit washer can beeliminated by using aerated grit chamber. It is designed for typical detention time of 3 minutes atmaximum flow. Grit hopper of about 0.9 m deep with steeply sloping sides is located along oneside of tank under air diffusers (Figure 15.6). The diffusers are located at about 0.45 to 0.6 m fromthe bottom. The size of particles removed will depend upon velocity of roll or agitation. The airflow rate can be easily adjusted to control efficiency and 100% removal of grit can be achieved.Wastewater moves in the tank in helical path and makes two or three passes across the bottom ofthetankatmaximumflow(andmoreatlessflow).

Wastewater is introduced in the direction of roll in the grit chamber. The expansion involume due to introduction of air must be considered in design. The aerated grit chambers areequipped with grit removal grab buckets, traveling on monorails over the grit collection andstoragetrough.Chainandbucketconveyerscanalsobeused.Twogritchambersinparallelareused to facilitate maintenance. Typical design details for aerated grit chamber are providedbelow (Metcalfand Eddy, 2003):

Depth:2to5 m
Length:7.5to20m
Width:2.5to7.0m
Widthtodepthratio:1:1to5:1
Detentiontimeatpeakflow:2to5 min (3 minutestypical)Airsupplym3/min.moflength:0.15to0.45 (0.3 typical)



FigureAeratedgritchamber(firstfigureshowingthehelicalflowpatternofthewastewateringrit chamberandsecondshowingcross sectionofgrit chamber)

Example:

Designaeratedgrit chamberfortreatmentofsewage withaverage flowof60MLD.Considerthepeakfactorof2.

Solution:

1. Averageflow =60MLD =0.694m3/sec,andPeakflow=0.694x2.0=1.389m3/sec
2. Volumeofgritchamber

Providetwochamberstofacilitateperiodiccleaningandmaintenance Provide detentiontime= 3.0min

Volumeofeachtank=1.389 x 3 x60 /2 = 125.01 m3

3. Dimensionsofaerationbasin:

Providedepthtowidthratioof1:1.2

Providedepth=3.0m,hencewidth=1.2x3.0=3.6mLength= 125.01 /(3 x 3.6) = 11.575 m

Increaselengthby20%toaccountforinletandoutletconditions.Totall ength= 11.575 x 1.2 =13.89 m.

4. Determine the air-supply requirementConsider0.3m3/min.oflength airsupply

Air Requirement = 13.89 x 0.3 = 4.17 m3/minProvideairswingarrangement at0.5m from floor

5. Quantityofgrit:

Considergritcollection0.015 /10^3 m3

Volumeofgrit=Peakflow xassumedgritcollection1.389 x 60 x 60 x 24 x 0.015 x10-3 = 1.8 m3/d

6. Checkforsurface overflowrate(SOR)

Thesettlingvelocityofthesmallestparticle= 2.4cm/sec,

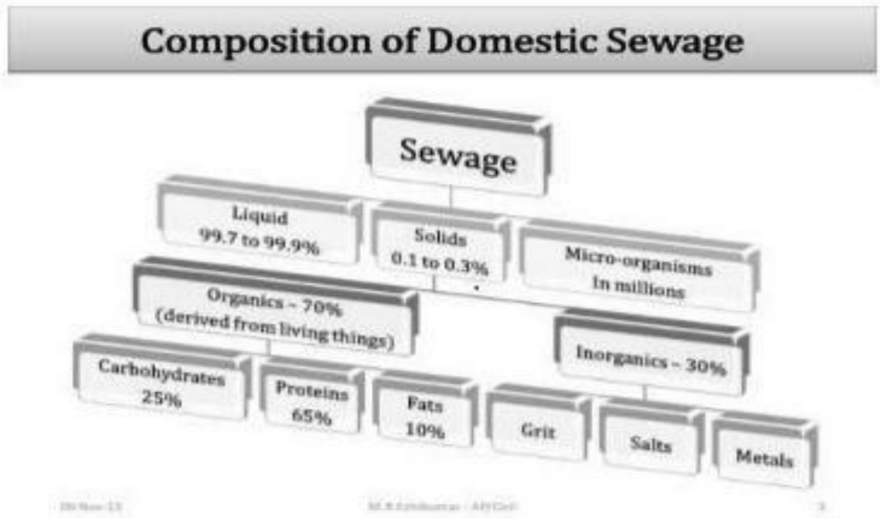
the actual SOR in the grit chamber = 1.389 / (2 x 3.6 x 11.575) = 0.0167 m/s = 1.67 cm/sec, whichisless thanthesettlingvelocityofthesmallestparticlehencedesignis safe.

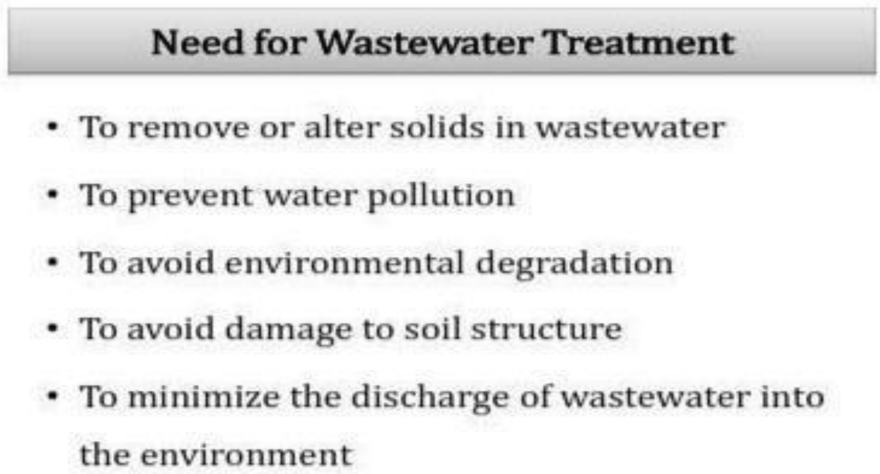
3.14.8 Vortex-TypeGritChamber

These types of grit chambers are used in small plants and these require lesser area as compared toearliertypes.Inthistype,gritisremovedwithvortexflowpattern.Thewastewaterenterstangentially and exit in the perpendicular direction of motion either from top or from side. Due toinertia the grit particles will remain in the chamber and liquid free from grit will only escape. Therotating turbine maintains constant velocity and helps in separating organic matter and grit. Thecentrifugalforceonthegritparticlecanalsobemaintainedwithoutturbinebyproperlyintroducing wastewater in the tangential direction in the chamber. Toroidal flow path is followedby the grit particles due to action of propeller (Metcalf and Eddy, 2003). Grit particle settles by theaction of gravity into hopper from where it is removed by a grit pump or air lift pump. Washedgrit,freefromtheorganicmatter, canbeobtainedfromthisdevice.

PRIMARYTREATMENT OFSEWAGE

The most modern of Watercare’s wastewater treatment plants– including the plants atMangere and Rosedale – use primary (mechanical), secondary (biological), tertiary (filtration) andultraviolet (radiation) methods to treat domestic and industrial wastewater (sewage) and stormwater. The average volume of wastewater treated is 300,000 cubic metres per day. Wastewatertreatment is designed to safeguard public health and to protect the environment. Wastewater(sewage)is99 percentwater and usuallycontains:





Organicmaterial– solid organic wastes such as food scraps, toilet wastes, paper etc. (includingleaves/wood etc from storm water infiltration). Food processing and textile industries contributelargequantitiesoforganicmaterials,iefruit/vegetablepulp, wooletc.

Grease and oils – household wastes contain cooking oil/ fat, soap and body oils from baths /showers.Industrialwastes cancontaingreasyorganiccompoundsandinorganic(mineral)oils.

Inorganic material – wastewater contains sand, silt and gravel (grit). Most of this comes fromstormwaterinfiltration.

Nutrients– ourbodiesneednutrientslikephosphorusandnitrogenandthesearenaturallyexcretedinourwastes. Someindustrialwastes alsocontainnutrients.

Metals – tiny amounts of metals, ie iron, copper and zinc, are naturally present in human wastes.Otherssuchaslead,chromiumandcadmiumcanbepresentfromstormwaterrun-offandindustry.

Chemicals – as a result of household cleaning (eg dish washing detergents and shampoos) orthrough process wastes fromindustry, many differentchemicals are containedin wastewater,someofwhicharetoxic.

Micro-organisms – bacteria, viruses and other micro- organisms that live in the human gut and areexcreted in large numbers. Most of these organisms are harmless and some are even beneficial.Sickpeople,however,canexcretelargenumbersofpathogenic(disease-causing)micro-organisms, which end up in the wastewater flow. The contents of the stream will vary dependingontheseason, day,timeand thetypeofindustries being served.

Pre-treatment

Pre-treatment, which includes screening and grit removal, is carried out at the start of thetreatment process. Pre-treatment is designed to remove solid objects, along with grease and oil,whichimpedeefficientwastewatertreatmentandareundesirableintheendproductbiosolids.

Removal of solid objects is also undertaken to protect machinery (especially pumpingequipment)andtopreventblockagesinSmallerpipesandchannels,whichtransportthewastewateraround thetreatmentplant.

Pre-treatmentalsoreduces thebiochemicaloxygendemand(BOD)ofthewastewater.BOD isameasureofthestrengthor pollutionpotentialofthewastewater.

Pre-treatment occurs when wastewater from Auckland's wastewater Interceptors enters amixing chamber at the start of processing. The interceptors – Western, Eastern, Southwestern andSouthern interceptors – are Auckland's main sewers (the Southern interceptor combines with theEasternbeforeitentersthetreatmentplant.)Odorousairandgasesareextractedatthispointandat numerous stages throughout the treatment process and passed through odour control biofilters.After the mixing chamber, the wastewater flows into six channels, each capable of taking 2,700litres per second.

UNIT-IV

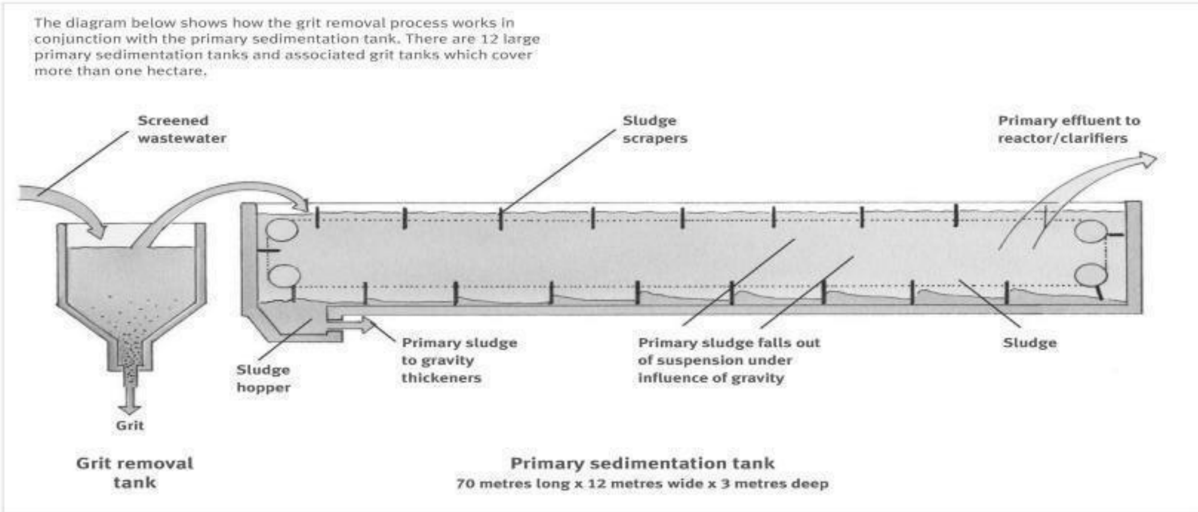
Primarysedimentationtanks

The 12 primary sedimentation tanks are each 70 metres long and 12 metres wide, with anaveragewaterdepthof2.8metres.Thesearelargetankswhicharedesignedtoallowthewastewater to flow slowly through in a smooth motion, free from turbulence enabling the organicsolids tosettletothebottom. Retentiontimeintheprimarytanksis twotothreehours.

Thesludgeiscollectedbytwoparallel,chain-drivenflightscrapers.Thesemovecontinuously along the sloping floors of the tanks, slowly ploughing the sludge towards the end ofthe tank where a cross collector (also chain and flight) moves the sludge into a deep hopper. Fromhere,itisremoved bynewcentrifugalpumpstoasludgesump.

Scum, which rises to the surface of the tanks, is directed by fan- shaped water jets to theinlet end of the tank. Here, it is lifted over a wall and into a trough by rotating scum collectors andcarried into the sludge sump. The sludge and scum from the primary Sedimentation tanks arepumped to the gravity thickeners. After the sludge has been thickened in the gravity thickeners, itis sent to the gravity belt thickenersfor further thickening before being sent to the digesters. Atthis stage, over 70 percent of the suspended solids have been separated from the liquid wastestreamwith40 percentoftheBODremoved.

After separation in the primary sedimentation tanks, the liquid stream is conveyed via theinterstage pump station at a rate of up to nine cubic metres per second to the reactor/clarifiers forsecondarytreatment. (Seetheinformationsheet*Secondarytreatment –liquid*).



Odourcontrol

Odour control is an important aspect of the wastewater treatment process. Odorous air iscollectedatvariousstagesoftreatmentbyventilationfansandductedtoboosterfans,whichpassitthrough earthfilters(biofilters).

There are six earth filter beds covering the primary treatment stage. Each filter bed is 800millimetre deep and divided in two sections. The filters cover a combined area of about 6,200squaremetres.

Each filter has been upgraded with new media (designed by Watercare scientists) made upof scoria and bark insteadof scoria and soil. Bark has the advantage over soil in that its quality ismore easilycontrolledanditallowsforalessdensemixture,givinglessresistencetoairflow.

Thenewimprovedbiofiltermediaismoreeffectiveandhasalongerworkinglife.Odorous air is evenly distributed beneath the media by a system of header and distribution pipes.Asitpercolatesupwards,theodorouscompoundsaretreatedby bacteriawithinthemedia.Odorous compounds are removed by physical and bacterial processes before being discharged toair. Biofilters also treat air extracted from other areas of the treatment plant including the pretreatment mixing chamber, gravity thickeners, the splitter boxes and the biosolids dewateringbuilding

SepticTank

- Primary Sedimentation tank
- Detention period – 12 to 36 hours
- Works on the principle of anaerobic decomposition
- Rectangular chambers – either single or multiple compartment type – constructed below GL
- Removes about 60 to 70% dissolved matter from it

Design Considerations

Number of souls per house hold: **5**

Number of fixtures per house hold: **1**

% of unit discharging simultaneously: **60**

Discharge from each unit: **10 Lpm at peak hours**

Surface area of sedimentation: **1 m^2/10Lpm of peak discharge**

Minimum depth for sedimentation: **30cm**

Minimum detention time: **24 hours**

Volume of fresh sludge: **0.0005m^3 / capita / day**

Digestion period: **45 days**

Digested sludge: **0.03 to 0.07 m^3 / capita / annum**

Minimum total volume of septic tank: **2 times the daily DF**

Cleaning interval: **1 to 4 years**

Length to width ratio: **2 to 3 : 1**

Recommended size of Septic Tank

No of Users	Length	Breadth	Liquid depth, m (Cleaning interval of)	
	m	m	2 years	3 years
5	1.5	0.75	1.0	1.05
10	2.0	0.90	1.0	1.40
15	2.0	0.90	1.3	2.00
20	2.3	1.10	1.3	1.80

Construction Aspects

- Baffle or tee is to penetrate at least 150mm below the liquid level
- Inspection pipes at the top of the tank
- No tank shall have more than 3 compartments
- Structure with more than 1 compartment produce better quality effluent
- First compartment is twice the size of second
- Liquid depth – 1.0 to 1.8m

Design a septic tank for a population of 150 in a housing colony.

Given:

Population of the colony: 150 persons

Solution:

Peak discharge = 150 x 1 x 0.6 x 10 / 5 = 180 Lpm

Surface area required = 180 / 10 = 18 m^2

At 30 cm depth for sedimentation,

Volume for sedimentation = 18 x 0.3 = 5.40 m^3

Volume for fresh sludge = 0.0005 x 150 x 45 = 3.38 m^3

Assume a cleaning interval of one year and sludge accumulation at 0.05 m^3 / capita / year,

Volume of digested sludge = 0.05 x 150 x 1 = 7.50 m^3

Total volume required = 5.40 + 3.38 + 7.50 = 16.28 m^3

Depth required = 16.28 / 18 = 0.90 m

Total depth including free board = 1.20 m

Result:

Size of the **first compartment** at L:W ratio of 2:1,

6.0 m x 3.0 m

Size of the **second compartment** is 50% of the first,

3.0 m x 3.0 m

Overall dimension of the septic tank,

9.0 m x 3.0 m x 1.20 m

SECONDARYTREATMENTOFSEWAGE

Thequalityofeffluentprovidedbysecondarytreatmentmaynotbealwayssufficienttomeetdischarge requirements.i.e.

Whenlargequantitiesaredischargedintosmallstreams Delicateecosystemsareencountered

Furthertreatmentmayberequiredtoremovenutrients (N,P),suspendedsolids,dissolvedinorganicsaltsand refractoryorganics

2.1NutrientRemoval

a. NitrogenRemoval

-Nitrification-denitrification

-AirStripping

b. PhosphorusRemoval

Thequalityofeffluentprovidedbysecondarytreatmentmaynotbealwayssufficienttomeetdischargerequirements.i.e.

Whenlargequantitiesaredischargedintosmallstreams Delicateecosystemsareencountered

Furthertreatmentmayberequiredtoremovenutrients (N,P),suspendedsolids,dissolvedinorganicsaltsand refractoryorganics

NitrogenRemovalusing Nitrification-Denitrification

Ammonification

Nitrogen compounds results in wastewater from biological decomposition of proteins andfromureadischargedinbodywaste.

This nitrogen is bound in complex organic molecules and is called **Organic Nitrogen**.While traveling through sewer pipes, the majority of organic-nitrogen is converted to ammoniathroughtheprocessof hydrolysis.

BiologicalCharacteristics

Microorganismsmaybeclassifiedaccordingtonutrientrequirements All organismsrequire:

AnEnergysource–for(1)maintenanceand(2)biosynthesis ACarbonSource–for growthofmicrobes

Heterotrophic – these are microorganisms that uses organic compounds as BOTH a carbonsource and as an energy source. These organisms are mostly employed in WWT **Chem-Autotrophs**–theseareorganismsthatusesinorganiccompoundsasBOTHanenergysourceandacarbonsource.

Nitrification

Typical wastewater influent can contain 85 mg/L total Nitrogen.Thoughconventionaltreatmentcanremove20–30%,Nitrification-Denitrificationcanremove70– 90%

Ammonia Nitrogen is the most reduced nitrogen compound found in wastewater. Thiscompound can be converted to Nitrogen by biological processes.This process is done in two (2)steps:

Ammonia is first oxidized to Nitrate Nitrate isreducedtomolecularNitrogen

Theorganismsresponsiblefornitrificationarechem-autotrophicbacteria,*nitrosomonas* and*nitrobacter*. Theseareaerobicbacteriaandthereforeneedfreeoxygentowork.

Ammonia Nitrogen can be biologically oxidized by chem-autotrophic bacteria to nitrates ifmolecularoxygenispresent:

These reactions require a great supply of oxygen. Contact time in secondary treatment may besufficient to convert organic nitrogen to ammonia nitrogen but not sufficient to convert ammonianitrogentonitrates.

This reaction consumes about 4.6 mg of O2 7.1 mg alkalinity per mg ammonia nitrogen.Underfavourableconditions this processcanbeaccomplishedincombinationwithcarbonaceousremoval in secondary systems. e.g. Extended Aeration System **or** done more efficiently, using aseparatenitrificationreactor.

De-Nitrification

Nitrateisreducedtonitrogengasbythesame facultative,heterotrophicbacteria involvedinoxidationofcarbonaceousmaterial.

Denitrificationoccurswhenoxygenlevelsaredepletedandnitratebecomestheprimaryoxygen sourcefor microorganisms.

Theprocessisperformedunderanoxic conditions,whenthedissolvedoxygenconcentrationisless than0.5mg/L,ideallyless than0.2.

When bacteria break apart nitrate (NO3-) to gain the oxygen (O2), the nitrate is reduced tonitrousoxide(N2 O),and,inturn,nitrogengas(N2).

For the process to proceed, the bacteria needs a carbon source. This can be obtained fromcarbonwithin thewasteor asmallamountofprimaryeffluentcanbeadded. Alternatively,ansourceofcarbon canbeprovided (Methanol).

After leaving the anoxic tank, the wastewater is aerated for 10 to 15 minutes to drive off theNitrogengas andaddoxygentothewastewaterbeforesedimentationTheAirStrippingProcess

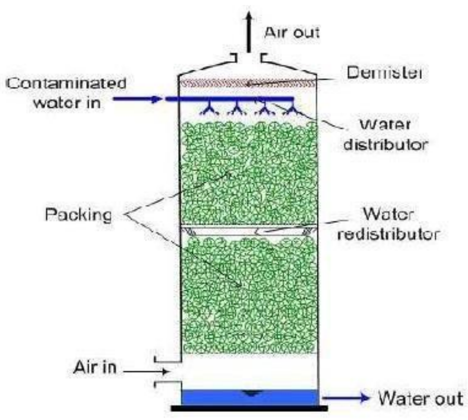
Theprocess consistofconvertingtheammoniumtothegaseous phaseandthendispersingtheliquidin air

ThegaseousphaseNH3andtheaqueousphaseNH4+existtogetherinequilibriumandthedominance of any one is dependent on pH and Temperature. A pH of >11 is required forcompleteconversiontoNH3

TheOperation

Limeis usedtoraisethepH to>11

Strippingofde-gasificationismostefficientlydoneusing acountercurrentspraytower.



DesignParametersare:

- 2000-6000m3ofair/m3wastewater
- TowerDepths >7.5m
- HRL40–46L/min/m2oftower
- **AdvantagesandDisadvantagesoftheairStripping**
- Airstrippingisthemosteconomicalmeansofremoving nitrogen, however, as temperatureapproaches freezing the efficiency dropssignificantly.
- Noisepollutionbyroaringfans.

- Airpollutionbyodorcausedbyreleaseofammoniagas.
- AdditionoflimecausesofteningofWWofalkalinity.

- Theprecipitationofcalciumcarbonate onthepackedmediathereforerequirescontinuouscleaning.

PhosphorusRemoval

CharacteristicsofPhosphatesinWW

- Phosphorus is a constituent of municipal wastewater, averaging around 15 – 10 mg/L. Itexistin3forms
- Organicallyboundphosphorus–Bodywasteandfoodwaste
- Polyphosphates-Usedextensivelyindetergentsandcontributes toabouthalfthephosphorusinWW
- Orthophosphates– Resultsduetobiologicaldecompositionoforganicallyboundphosphates andhydrolysisofpolyphosphates
- Thus,theprincipalphosphate foundinWW isOrthophosphates
- Orthophosphates consist of (phosphate) PO3-4 , HPO42- and H2 PO4- and formchemicalbondswithcations and positiveradicals.
- These compounds are highly soluble, thus negligible removal occurs in primarytreatment.However,<3mg/Lisremovedinbiomassfromsecondarytreatmentduet outilizationbymicroorganisms.

AtSlightlyAcidicpH

- Chemical precipitation is the principal method used to remove phosphorus. At slightlyacidic pH, orthophosphates combine with trivalent aluminum or iron cations to form appt.
- Sincedomesticwastewateronlycontainstraceamountsofironandaluminum,thus,
- Alum(aluminumsulphate)orFerricChloridewillhavetobeadded.

AtHigherpH

- CalciumformsaninsolublecomplexwithphosphateatpH>9.0.
- TheadditionoflimecanprovidebboththecalciumandPhadjustments necessary.

ProcessSelection

- Theremovalofphosphorus canoccuras partoftheprimaryorsecondarytreatmentprocess or as a tertiary process. The choice of process depends on efficiencyrequirements,

  a. Ifupto1mg/Lis acceptablefordischarge,ironoraluminumsalts addedtotheprimaryor secondaryprocessis oftendone.

  b. Ifgreaterefficiencyisneeded,tertiarysystem isemployedwiththe additionoflime.

SolidsRemoval-SuspendedSolidsRemoval

- Theremovalofsuspended solidsfromwastewaterreferstotheremovalofparticles andfloctosmallortoolightweighttoberemovedingravitysettling.
- Theseparticlesmayhavebeenbroughtoverfromsecondarytreatmentorppt intertiarytreatment.

Methodsofremoval

1. Centrifugation
2. AirFloatation
3. MechanicalMicrostraining
4. Filtration(mostcommon)

Filtration

SlowSandFilters

- Thismethodismostsuccessfulasapolishingstepinoxidationponds.

- (Notsuitableforeffluentfromconventionaltreatmentduetoclogging)

Granular-mediaFiltration

Thebedcompriseduelormultimediabedsandismostsuitedforeffluentfromsecondarytreatment

MovingBedFilters

Thesearecontinuouscleaned,withtherateofcleaningadjustedtomatchthesolidsloadingrate.This systemastheabilitytofilterrawsewage.

Pulse-bedFilters

Compressedairisperiodicallyinjectedtobreakupthethinsurfacematofdeposits.Thissystemastheabilitytofilterrawsewage.

SolidsRemoval-DissolvedSolidsRemoval

Secondary treatment as well as nutrient removal decreases the dissolved organic solidspresent in WW. However, neither process completely removes ALL organic dissolved solids ORsignificantamountsof inorganicdissolvedsolids.

Ifsubstantialreductionindissolvedsolidsisrequired,furthertreatmentwouldbe needed. These techniquesaresimilartothatusedinthe advancedtreatment ofWaterforremoval:IonExchange

MicroporousMembrane

FiltrationAdsorption

Chemical

OxidationChemical

Oxidation

This technique can be used as an alternative to adsorption for the removal of refractoryorganic compounds from water and wastewater treatment system The target contaminants include;largecomplexorganic,ring-structureddetergents,phenolic&humiccompounds.Thesearebrokendownintosimplecompounds bystrongoxidantse.g.Ozone, Chlorine.

AdvantageandDisadvantages

Advantages

Removalofammonia

Oxidation

ofinorganicsubstancesasironandmanganeseDisinfection

Disadvantage

ChlorinereactswithsomeorganicstoformhaloformHig

hdoses of ozoneisrequired3:1

WastewaterDisposal

Themostcommonmethodofdisposalisbydilution.Disposaltoastreamisdependentofthe levelofdilutioncapablebythestreamaswellas thesensitivityofthestreamtosmallchanges Otherwise,tertiarytreatmentmaybeneededbeforedischarge.Thisisnormallyintheformofnutrientremoval.

NaturalEvaporation

Theprocessismostusefulinclimateswhereevaporationexceedsprecipitation.

Thesystemis essentiallylargeoxidationpondswithasurfaceareasuitedtotherateofinflow.

OceanDisposal

This is a efficient and cost effective method. The effluent is transported out to seaby pipelines along the ocean floor and discharged at multiple points. The length of theoutfalldependsontheoceancurrentsandvolumeofwastewater.

LandApplication

Landapplicationcanbeaformofdisposalas wellas amethodofreuse.TheseincludeIrrigationand RapidInfiltration

Irrigation

1. Wastewaterisappliedtolandsurfacetoprovidebothwaterandnutrients forplantgrowth.
2. Applicationsincludeagriculture,civilculture;maintainvegetationinparks,golfcourses,alongroadways and airportrunways.
3. In most cases food chain crops (i.e. crops consumed by humans and those animals whoseproducts are consumed by humans) may not be irrigated by effluent. However, field crops such ascotton,sugarbeets,andcropsforseed productionaregrownwithwastewater effluent.

UNIT

VIDISPOSALOFSEWAGEANDSLUDGE

As research into the characteristics of wastewater has become more extensive, and as thetechniques for analyzing specific constituents and their potential health and environmental effectshave become more comprehensive, the body of scientific knowledge has expanded significantly.Manyofthenewtreatmentmethodsbeingdevelopedaredesignedtodealwithhealth andenvironmental concerns associated with findings of recent research. However, the advancement intreatment technology effectiveness has not kept pace with the enhanced constituent detectioncapability. Pollutants can be detected at lower concentrations than can be attained by availabletreatmenttechnology.Therefore,carefulassessmentofhealthandenvironmenteffectsandcom munityconcernsabouttheseeffectsbecomesincreasinglyimportantinwastewatermanagement. The need to establish a dialogue with the community is important to assure thathealthand environmentalissuesarebeing addressed.

Water quality issues arise whenincreasing amounts of treated wastewater are dischargedto water bodies that are eventually used as water supplies. The waters of the Mississippi River andmany riversin the eastern United States are usedfor municipal andindustrial water supplies andas repositories for the resulting treated wastewater. In southern California, a semiarid region,increasingamountsofreclaimedwastewaterarebeingusedorareplannedtobeusedforgroundwate r recharge to augment existing potable water supplies. Significant questions remainaboutthetestingandlevelsoftreatmentnecessarytoprotecthumanhealthwherethecommingling of highly treated waste- water with drinking water sources results in indirect potablereuse.

WASTEWATERCHARACTERISTICS

Prior to about 1940, most municipal wastewater was generated from domestic sources.After 1940, as industrial development in the United States grew significantly, increasing amountsofindustrialwastewaterhavebeenandcontinuetobedischargedtomunicipalcollectionsystems.

The amounts of heavy metals and synthesized organic compounds generated by industrialactivitieshave increased,and some 10,000 new organic com- pounds are added each year. Manyof these compounds are now found in the wastewater from most municipalities and communities.As technological changes take place in manufacturing, changes also occur in the compoundsdischarged and the resulting wastewater characteristics. Numerous compounds generated fromindustrialprocessesaredifficultandcostlytotreatbyconventionalwastewatertreatmentprocesses. Therefore, effectiveindustrial pretreatment becomes an essential partof an overallwaterquality managementprogram.Enforcementofanindustrialpretreatmentprogramisadaunting task, and someof the regulatedpollutants still escape to the municipal wastewatercollection system and must be treated. In the future with the objective of pollution prevention,every effort should be made by industrial dischargers to assess the environmental impacts of anynew com- pounds that may enter the wastewater\ stream before being approved for use. If a com-poundcannotbetreated effectivelywithexisting technology,itshouldnotbeused.

ImprovedAnalyticalTechniques

Great strides in analytical techniques have been made with the development of new andmoresophisticatedinstrumentation.Whilemostconstituentconcentrationsarereportedinmilligrams perliter(mg/L),measurementsinmicrogramsperliter(μg/L)andnanogramsper liter (ng/L) are now common. As detection methods become more sensitive and a broader range ofcompoundsaremonitoredinwatersupplies,morecontaminantsthataffecthumansandtheenvironment will be found. Many trace compounds and microorganisms, such as *Giardia lamblia*and *Cryptosporidium parvum*, have been identified that potentially may cause adversehealtheffects. Increased analytical sophistication also allows the scientist and engineer to gain greaterknowledge of the behavior of wastewater constituents and how they affect process performanceandeffluentquality.

ImportanceofImprovedWastewaterCharacterization

Because of changing wastewater characteristics and the imposition of stricter limits on wastewaterdischarges and biosolids that are used beneficially, greater emphasis is being placed on wastewatercharacterization. Because process modeling is widely used in the design and optimization ofbiological treatment processes (e.g., activated sludge), thorough characterization of wastewater,particularlywastewaters containingindustrialwaste,isincreasinglyimportant.

Process modeling for activated sludge as it is currently conceived requires experimentalassessment of kinetic and stoichiometric constants. Fractionization of organic nitrogen, chemicaloxygen demand (COD), and total organic carbon into soluble and particulate constituents is nowused to optimize the performance of both existing and proposed new biological treatment plantsdesigned to achieve nutrient removal. Techniques from the microbiological sciences, such as RNAandDNAtyping,arebeing usedtoidentifytheactivemassinbiologicaltreatmentprocesses.

WastewaterDisinfection.

Changes in regulations and the development of new technologies have affected the designof disinfection systems. Gene probes are now being used to identify where specific groups oforganismsarefoundin treated secondary effluent(i.e.,in suspension or particle-associated).Historically, chlorine has been the disinfectant of choice for wastewater. With the increasingnumberofpermitsrequiringlowornondetectableamountsofchlorineresidualintreatedeffluents,dechlorinationfacilitieshavehadtobeadded,orchlorinationsystemshavebeenreplaced by alternative disinfection systems such as ultraviolet (UV) radiation (see Fig. 1–6). Con-cernsaboutchemicalsafetyhavealsoaffecteddesignconsiderationsofchlorinationanddechlorination systems. Improvements that have been made in UVlamp and bal-last designwithinthepast10yearshaveimprovedsignificantlytheperformanceandreliabilityof UVdisinfection systems. Effective guidelines have also been developed for the application and designofUVsystems(NWRI,2000).Capitalandoperatingcostshavealsobeenlowered.Itisanticipated that the application of UV for treated drinking water and for storm water will continueto increase in the future. Because UV produces essentially no troublesome byproducts and is alsoeffective in the reduction of NDMA and other related compounds, its use for disinfection is furtherenhancedascompared tochlorinecompounds.

CombinedSewerOverflows(CSOs),SanitarySewerOverflows(SSOs),andNonpointSources.

Overflowsfromcombinedsewerandsanitarysewercollectionsystemshavebeenrecognized as difficult problems requiring solution, especially for many of the older cities in theUnited States. The problem has become more critical as greater development changes the amountand characteristics of storm water runoff and increases the channelization of runoff into storm,combined, and sanitary collection systems. Combined systems carry a mixture of wastewater andstorm water runoff and, when the capacity of the interceptors is reached, overflows occur to thereceivingwaters.Largeoverflows canimpactreceivingwaterqualityandcanpreventattainment ofmandatedstandards.Recreationalbeachclosingsandshell-fishbedclosureshavebeenattributedtoCSOs(LapeandDwyer,1994).FederalregulationsforCSOsarestillunderdevelopmentandhavenotbeenissuedatthetimeofwritingthis text(2001).

A combination of factors has resulted in the release of untreated wastewater from parts ofsanitary collection systems. These releases are termed sanitary system over- flows (SSOs). TheSSOs maybecaused by(1)theentranceofexcessiveamountsofstormwater, (2)blockages,or (3) structural, mechanical, or electrical failures. Many overflows result from aging collectionsystems that have not received adequate upgrades, maintenance, and repair. The U.S. EPA hasestimated that at least 40,000 overflows per year occur from sanitary collection systems. Theuntreatedwastewaterfromtheseoverflowsrepresentsthreatstopublichealthandtheenvironment. The U.S. EPA is proposing to clarify and expand permit requirements for municipalsanitary collection systems under the Clean Water Act that will result in reducing the frequencyand occurrence of SSOs (U.S. EPA 2001). At the time of writing this text (2001) the pro-posedregulations are under review. The U.S. EPA estimates that nearly $45 billion is required forconstructingfacilitiesforcontrolling CSOs andSSOs intheUnitedStates (U.S.EPA,1997).

Theeffectsofpollutionfromnonpointsourcesaregrowingconcernsasevidencedbytheoutbreakofgastrointestinalillnessin Milwaukeetracedtotheoocysts of*Cryp-tosporidiumparvum*,andtheoccurrenceof*Pfiesteriapiscicida*inthewatersofMary-landandNorthCarolina.*Pfiesteria*isaformofalgaethatisverytoxictofishlife.Runofffrompasturesandfeedlots has been attributed as a potential factor that triggers the effects of these microorganisms.**FutureTrendsinWastewaterTreatment**

IntheU.S.EPANeeds AssessmentSurvey,thetotaltreatmentplantdesigncapacityis projectedtoincreasebyabout15percentoverthenext20to30years .Duringthis period,theU.S.EPA estimates that approximately 2,300 new plants may have to be built, most of which will beproviding a level of treatment greater than secondary. The design capacity of plants providinggreater than secondary treatment is expected to increase by 40 percent in the future (U.S. EPA,1997). Thus, it is clear that the future trends in wastewater treatment plant design will be forfacilities providinghigherlevelsoftreatment.

Some of the innovative treatment methods being utilized in new and upgraded treatmentfacilities include vortex separators, high rate clarification, membrane bioreactors, pressuredrivenmembrane filtration (ultra filtration and reverse osmosis), and ultraviolet radiation (lowpressure,low-andhigh-intensityUVlamps,andmedium-pressure, high-intensityUV lamps).

Someofthenew technologies,especiallythosedevelopedinEurope,aremorecompactandareparticularlywellsuitedforplantswhereavailablespaceforexpansionislimited.

In recent years, numerous proprietary wastewater treatment processes have been developedthatofferpotentialsavingsinconstructionandoperation.Thistrendwilllikelycontinue,particularlywherealternativetreatmentsystems areevaluatedorfacilities areprivatized.

Privatizationisgenerally definedasa public-private partnershipin which the privatepartner arranges the financing, design, building, and operation of the treatment facilities. In somecases, the private partner may own the facilities. The reasons for privatization, however, go wellbeyond the possibility of installing proprietary processes. In the United States, the need for privatefinancing appears to be the principal rationale for privatization; the need to preserve local controlappears tobetheleadingpragmaticrationaleagainstprivatization.

WASTEWATERRECLAMATIONANDREUSE

In many locationswhere the available supply of fresh water hasbecomeinadequate tomeetwaterneeds,itisclearthattheonce-usedwatercollectedfromcommunitiesandmunicipalities must be viewed not as a waste to be disposed of but as a resource that must bereused. The concept of reuse is becoming accepted more widely as other parts of the countryexperiencewater shortages.Theuseofdualwater systems, suchasnow used inSt.

Petersburg in Florida and Rancho Viejo in California, is expected to increase in the future.In both locations, treated effluent is used for landscape watering and other non potable uses.Satellite reclamation systemssuch asthose usedin the LosAngelesbasin,where wastewaterflows are mined (withdrawn from collection systems) for local treatment and reuse, are exampleswhere transportation and treatment costs of reclaimed water can be reduced significantly. Becausewater reuse is expected to become of even greater importance in the future, reuse applications areconsideredinChap. 13.

CurrentStatus

Most of the reuse of wastewater occurs in the arid and semiarid western and southwesternstates of the United States; however, an increasing number of reuse projects are occurring in thesouth including Florida and South Carolina. Because of health and safety concerns, water reuseapplications are mostly restricted to non potable uses such as landscape and agricultural irrigation.InareportbytheNationalResearchCouncil(1998),itwasconcludedthatindirectpotablereuseo freclaimedwater(introducingreclaimedwatertoaugmentapotablewatersourcebeforetreatment) is viable. The report also stated that direct potable reuse (introducing reclaimed waterdirectly into a water distribution system) was not practicable. Because of the concerns aboutpotential health effects associated with the reclaimed water reuse, plans are proceeding slowlyabout expanding reuse beyond agricultural and landscape irrigation, groundwater recharge forrepellingsaltwaterintrusion,andnonpotable industrialuses(e.g.,boilerwaterandcoolingwater).

NewDirectionsandConcerns

Many of the concerns mentioned in the National Research Council (NRC, 1998) reportregarding potential microbial and chemical contamination of water supplies also apply to watersources that receive incidental or unplanned wastewater discharges. A number of communities usewater sources that contain a significant wastewater component. Even though these sources, aftertreatment, meet current drinking water standards, the growing knowledge of the potential impactsofnewtracecontaminantsraisesconcern.Conventionaltechnologiesforbothwaterandwastewat er treatment may be incapable of reducing the levels of trace contaminants below wherethey arenotconsidered as a potential threatto publichealth. Therefore,new technologies thatoffer significantly improved levels of treatment or constituent reduction need to be tested andevaluated. Where indirect potable reuse is considered, risk assessment also becomes an importantcomponentofawater reuseinvestigation.

FutureTrendsinTechnology

Technologies that are suitable for water reuse applications include membranes (pressuredriven, electrically driven, and membrane bioreactors), carbon adsorption, advanced oxidation, ionexchange, and air stripping. Membranes are most significant develop- ments as new products arenow available for a number of treatment applications. Mem- branes had been limited previously todesalination,buttheyarebeing testedincreasinglyfor wastewaterapplicationsto produce high-quality treated effluent suitable for reclamation. Increased levels of contaminantremovalnotonlyenhancetheproductfor reusebutalsolessenhealthrisks.

BIOSOLIDSANDRESIDUALSMANAGEMENT

The management of the solids and concentrated contaminants removed by treatment hasbeenandcontinuestobeoneofthemostdifficultandexpensiveproblemsinthefieldofwastewater engineering. Wastewater solids are organic products that can be used beneficially afterstabilization by processessuch asanaerobic digestion and com-posting. With the advent ofregulations that encourage biosolids use, significant efforts have been directed to producing a“cleansludge”thatmeetsheavymetalsandpathogenrequirementsandissuitableforlandapplication. Regulations for Class B biosolids call for reduced density in pathogenic bacteria andenteric viruses, but not to the levels of Class A biosolids. Further, the application of Class Bbiosolids to land is strictly regulated, and distribution for home use is prohibited. Other treatmentplant residuals such as grit and screenings have to be rendered suit- able for disposal, customarilyin landfills. Landfills usually require some form of dewatering to limit moisture content. With theincreased use of membranes, especially in wastewater reuse applications, a new type of residual,brineconcentrate, requires further processing anddisposal.

Solarevaporation pondsanddischargeto asaltwaterenvironmentareonly viableincommunities where suitable and environmental geographic conditions prevail; brine concentrationandresidualssolidificationaregenerallytoocomplexand costlytoimplement.

CurrentStatus

Treatment technologies for solids processing have focused on traditional methods such asthickening, stabilization, dewatering, and drying. Evolution in the technologies has not occurred asrapidlyasinliquidtreatmentprocesses,butsomesignificantimprovementshaveoccurred.Centrifuges that produce a sludge cake with higher solids content, egg -shaped digesters thatimprove operation, and dryersthat minimize watercontent arejust a fewexamplesof productsthat have come into use in recent years. These developments are largely driven by the need toproducebiosolids thatareclean,haveless volume,and canbeusedbeneficially.

Landfills still continue to be used extensively for the disposal of treatment plant solids,eitherin sludge-only mono fillsor with municipal solid waste. Thenumber and capacity oflandfills, however, have been reduced, and new landfill locations that meet public and regulatoryacceptance and economic requirements are increasingly difficult to find. Incineration of solids bylarge municipalities continues to be practiced, but incineration operation and emission control issubject to greater regulatory restrictions and adverse public scrutiny. Alternatives to landfills andincineration include land application of liquid or dried biosolids and composting for distributionand marketing. Land application of biosolids is used extensively to reclaim marginal land forproductive uses and to utilize nutrient content in the biosolids. Composting, although a moreExpensivealternativeisameansofstabilizinganddistributingbiosolidsforuseasasoilamendment. Alkaline stabilization of biosolids for land application is also used but to a lesserextent.

NewDirectionsandConcerns

Overthelast30years,theprincipalfocusinwastewaterengineeringhasbeenonimproving the quality of treated effluent through the construction of secondary and advancedwastewater treatment plants. With improved treatment methods, higher levels of treatment must beprovided not only for conventional wastewater constituents but also for the removal of specificcompoundssuch asnutrientsandheavymetals.A by-productof theseeffortshasbeentheincreasedgenerationofsolids and biosolids perpersonservedbyamunicipalwastewater system. In many cases, the increase in solids production clearly taxes the capacity of existingsolids processing and disposalmethods.

Inadditiontotheshearvolumeofsolidsthathastobehandledandprocessed,management options continue to be reduced through stricter regulations. Limitations that affectoptions are:
(1) landfill sites are becoming more difficult to find and have per- mitted, (2) air emissions fromincinerators are more closely regulated, and (3) new requirements for the land application ofbiosolids have been instituted. In large urban areas, haul distances to landfill or land applicationsites have significantly affected the cost of solids processing and disposal. Few new incineratorsare being planned because of difficulties in finding suitable sites and obtaining permits. Emissioncontrol regulations of the Clean Air Act also require the installation of complex and expensivepollutioncontrolequipment.
More communities are looking toward (1) producing Class A biosolids to improve beneficial reuseopportunities or (2) implementing a form of volume reduction, thus lessening the requirements fordisposal. The issue—“are Class A biosolids clean—will be of ongoing concern to the public. Thecontinuing search for better methods of solids processing, disposal, and reuse will remain as one ofthe highest priorities in the future. Additionally, developing meaningful dialogue with the publicabouthealthand environmentaleffectswillcontinuetobeveryimportant.

FutureTrendsinBiosolidsProcessing

Newsolidsprocessingsystemshavenotbeendevelopedasrapidlyasliquidunitoperationsand processes. Anaerobic digestion remainsthe principal processforthe stabilizationofsolids.

Egg-shaped digesters, developed in Europe for anaerobic digestion, are being used moreextensively in the United States because of advantages of easier operation, lower operation andmaintenance costs, and, in some cases, increased volatile solids destruction (which also increasesthe production of reusable methane gas) (see Fig. 1–8). Other developments in anaerobic andaerobicdigestionincludetemperature-phasedanaerobicdigestionandautothermalaerobicdigestion (ATAD), another process developed in Europe. These processes offer advantages ofimproved volatile solids destruction and the production of stabilized biosolids that meet Class Arequirements.

High solids centrifuges and heat dryers are expected to be used more extensively. Highsolids centrifuges extract a greater percentage of the water in liquid sludge, thus providing a dryercake. Improved dewatering not only reduces the volume of solids requiring further processing anddisposal, but allows composting or subsequent drying to be performed more efficiently. Heatdrying provides further volume reduction and improves the quality of the product for potentialcommercialmarketing