WASTEWATER TREATMENT BY PHYTOREMEDIATION IN A CONSTRUCTED WETLAND

A Comparative Study using *Chrysopogon zizanioides* (Vetiver) and *Phragmites karka* (Common reed)

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Introduction

- Wastewater: Discharged after use
- Wetlands: Storehouse of organic nutrients
- Constructed wetlands: Mimic of natural wetlands
- Phytoremediation: nutrient absorption by plants and microorganisms
- *Chrosopogon zizanioides* (Vetiver) and *Phragmites karka* (Common reed) widely used for wastewater treatment in many countries

Vetiver

Common reed

Objective

- **Broad Objective**
- Determine the wastewater treatment efficiency of *Chrysopogon zizanioides* (Vetiver) and *Phragmites karka* (Common reed) in Constructed Wetland System.
- **Specific objectives**
- Study the morphological changes (Height, Lateral growth, Leaf colour, Decay and new growth) in the Vetiver and Common reed at weekly interval
- Analyze Physical (pH, Temperature, Conductivity) chemical (BOD, Chemical oxygen Demand, Nitrate-N, Total Phosphorus, Chloride, Carbondioxide) and Microbial (Total Coliform) Parameters of wastewater before and after treatment at an interval of two weeks after three month of plantation
- Analyze soil nutrient change (Percent Organic matter, percent organic Carbon, percent Total Nitrogen and Average Phosphorus) in relation to change in morphology of plants and change in chemical concentration of water

Statement of Problem

- Human sanitary wastes, Sewerage, Industrial effluents are main cause of water pollution
- Bagmati river quality: COD(110-197.62), TSS (92-3000), NO3 (0.6-1.25) mg/l since 2003-2013 (ENPHO, 2003;Ghimire. N., 2013)
- Bagmati and its tributaries around Kathmandu being degraded
- Kathmandu Valley had five municipal wastewater treatment plants (WWTP). Activated sludge system at Guheshwori only operated (Aratha, 2003)
- Conventional methods very costly, require good technical knowledge on handling the process
- Natural, easy and low cost method needed which is best done by phytoremediation in Constructed wetland system
- Biological treatment of wastewater using constructed wetland system is cost effective, efficient and easy in operation

Significance of Study

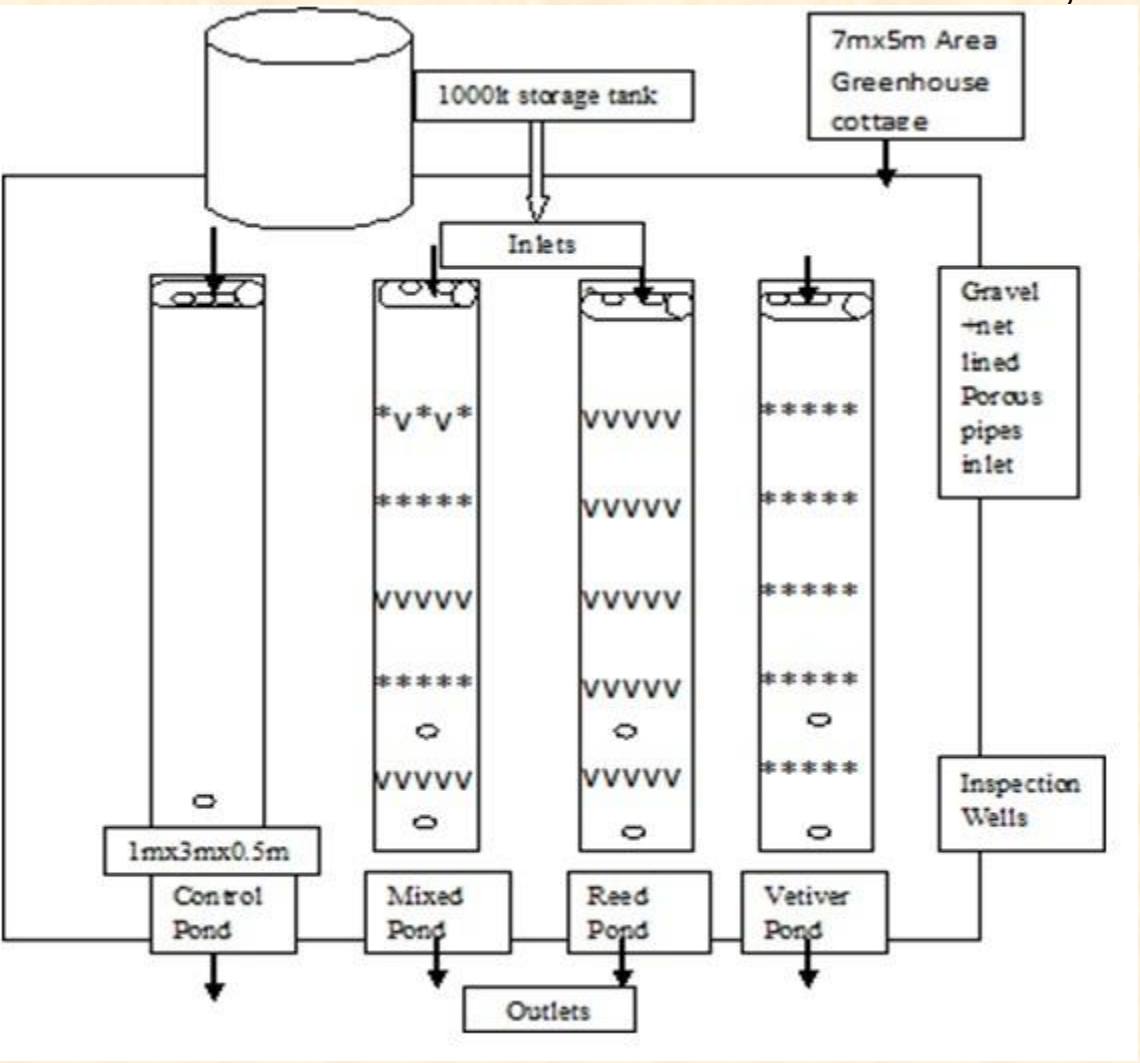
- Phytoremediation- natural process, no additional technical assistance once planted properly with appropriate planning
- water quality of natural streams improved
- Beneficial for agriculture, social, environment and economic sectors
- Would be helpful for further research
- Treatment and recycling of wastewater would be encouraged
- Being cost effective method, it can apply anywhere as required
- Meet water demand without deteriorating the natural systems

Limitation of Study

- The research was conducted in very small scale on experimental basis.
- The research duration was only for six month from March to August.
- The constraints due to mixing of rainwater from the drainage outlets system from the building and the ground water flow during Monsoon did not considered.

Study Area

Constructed Wetland in NW corner of Block A, Khwopa

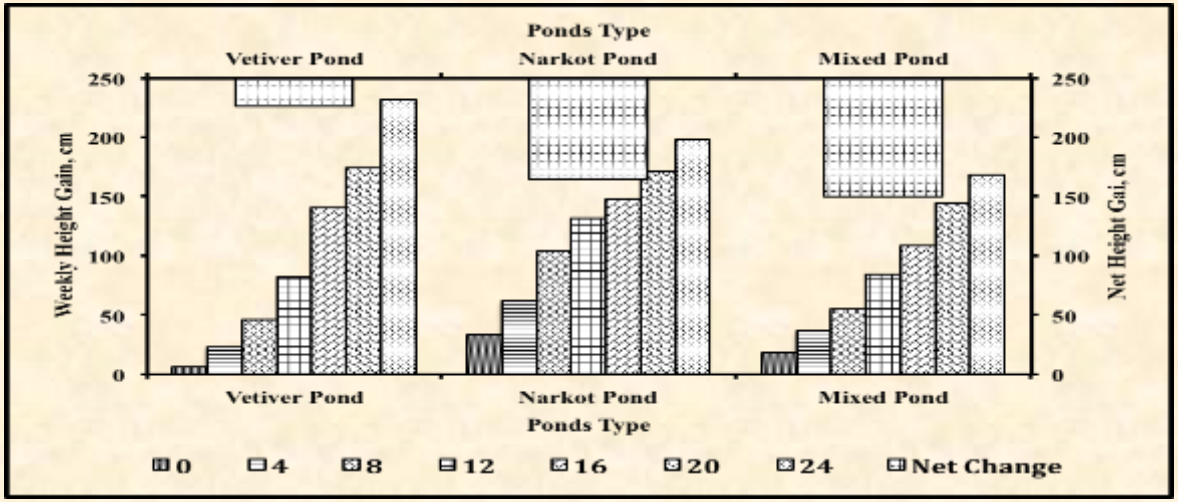


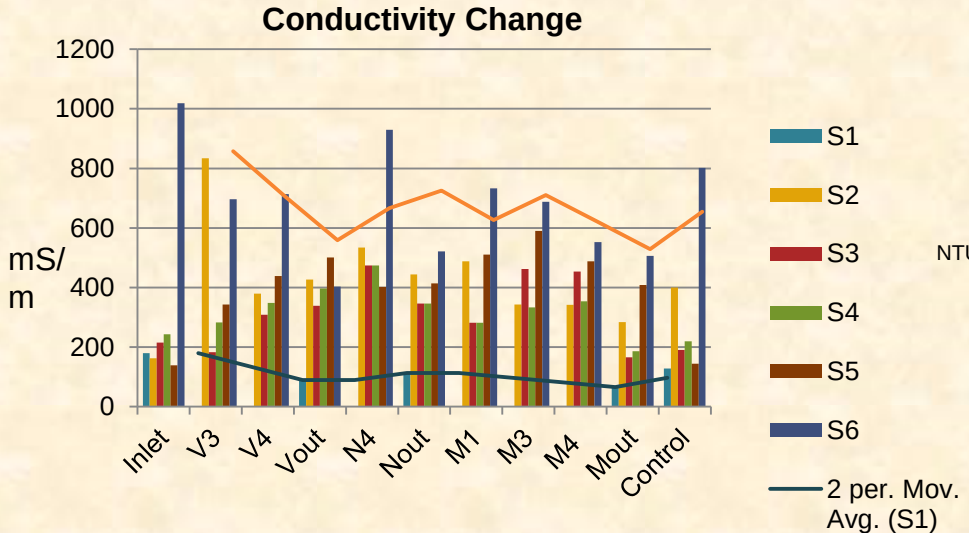
Data Collection Technique

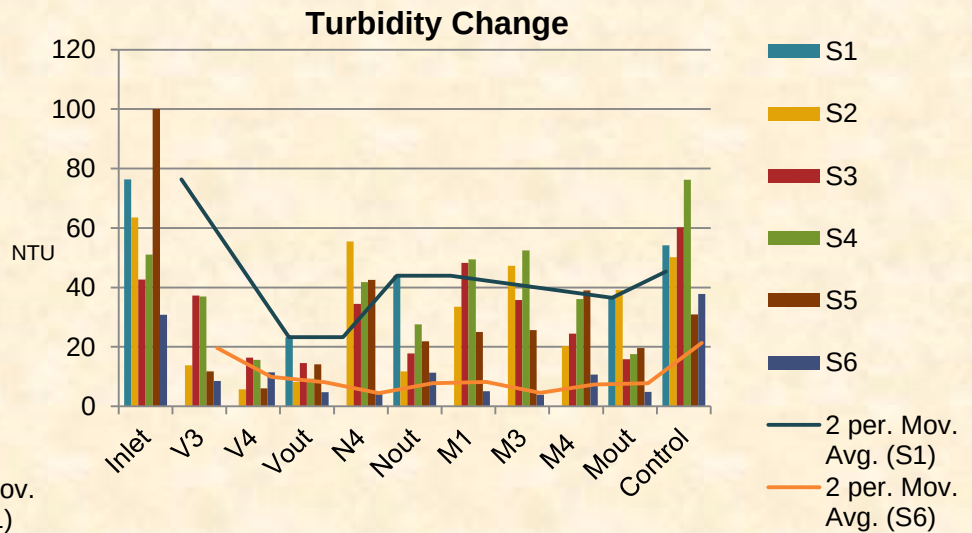
S.No	Objective	Method	Tools and methodologies
1	Study the morphological changes in the Vetiver and Common reed at weekly interval	Site Observation	Measuring plants height and hedge at weekly interval
2	Determining Physiochemical parameters before and after treatment	APHA, AWWA and WEF (2005) MF method	Determining pH. EC, Turbidity, BOD, COD, NO3 ,TP, CO2, Cl and coliform at two weeks interval
3	Analyze soil nutrient change in relation to change in morphology of plants and change in chemical concentration of water	Walkley and Black Method, Comparison and Statistical analysis	MS-Excel 2007, SPSS 20 and R 1.12.1 for T-Test, Scatter Diagram and ANOVA

Major Findings

- Average Growth rate: Vetiver**225.8±9.66**cm, Common reed= **164.6±7.35** 48cm Mixed=**149.83±34.36**cm,
- Max Height: Vetiver=245cm, Common reed=208cm(Planted individually) and Vetiver=200cm, Narkot= 175cm(mixed plantation)





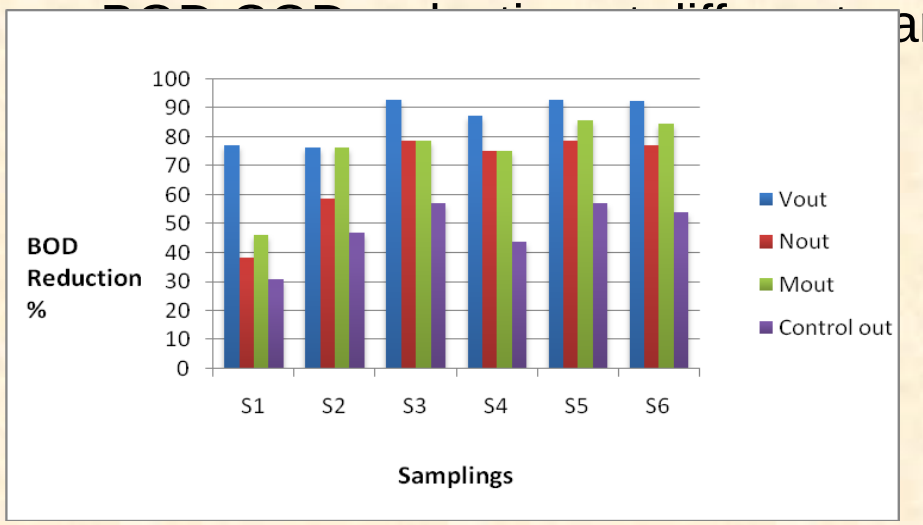


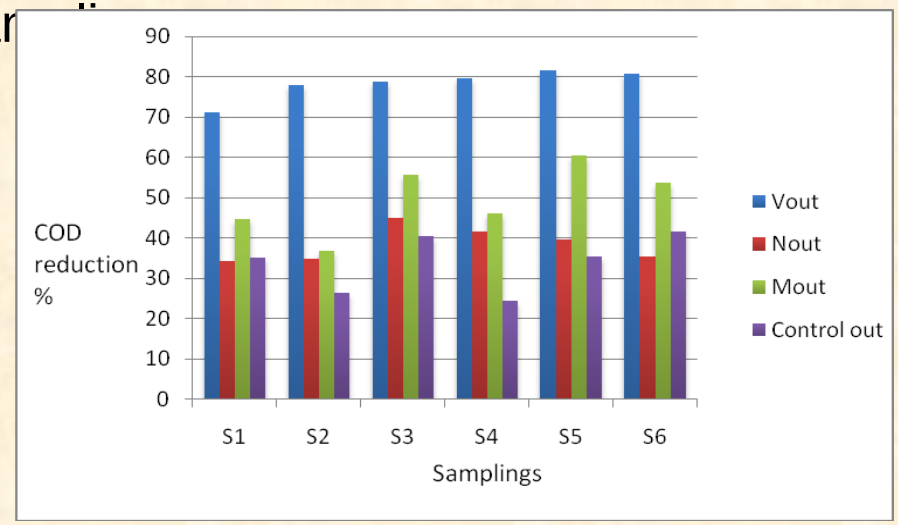
Chemical Parameters

- On the sixth month the overall concentration of BOD5, COD, NO_3- N, TP, Free CO_2, Chloride content and EC in the effluent after treatment were reduced by

Treatment Ponds	% REDUCTION					
	BOD5	COD	NO3-N	TP	CO2	Cl-
Vetiver	92.30	80.76	90.90	78.12	87.5	81.13
Narkot	76.92	35.38	81.18	55	56.25	52.83
Mixed	84.61	53.84	84.09	60	62.5	60.37
Control	53.84	28.12	30	32.5	28.12	26.41

- BOD COD reduction at different [illegible]

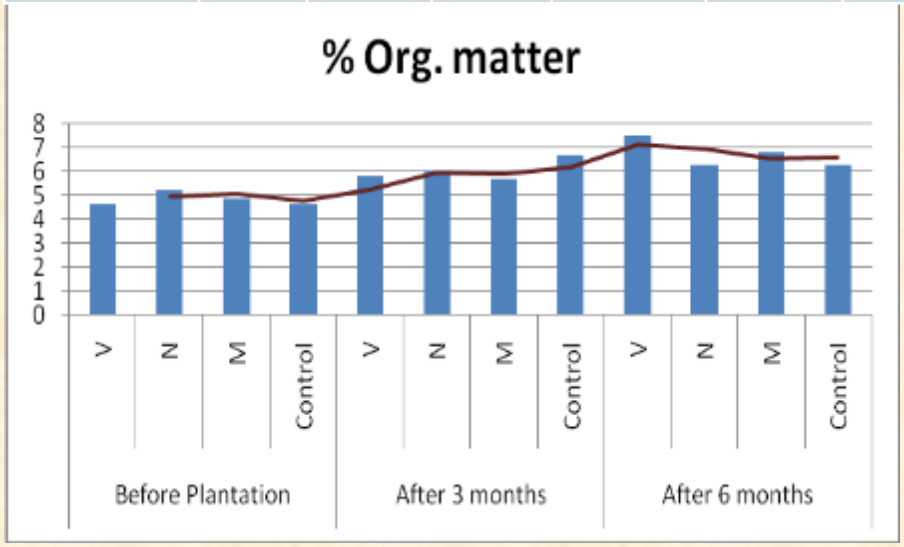


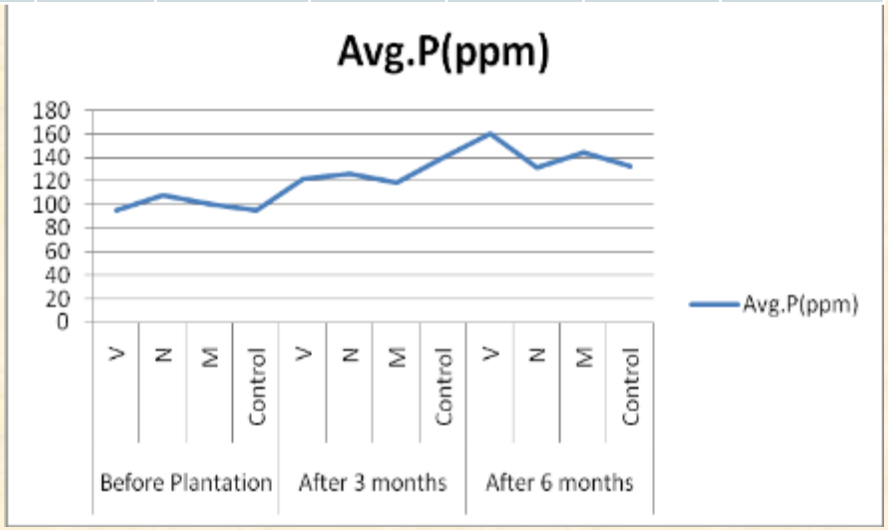


- Treatment efficiency: Mixed > Narkot > Control

Soil Nutrients change

	Before Plantation				After 3 months				After 6 months			
	V	N	M	Control	V	N	M	Control	V	N	M	Control
% Org. matter	4.64	5.23	4.86	4.64	5.82	6.04	5.67	6.67	7.55	6.26	6.81	6.30
%nOrg. Carbon	8.00	9.02	8.38	8.00	10.03	10.41	9.78	11.49	13.02	10.80	11.75	10.86
Avg.P(ppm)	95.0	108.1	99.9	95.0	121.3	126.2	118.0	140.2	160.0	131.2	143.5	132.0
TN%	0.34	0.38	0.35	0.34	0.42	0.43	0.41	0.47	0.53	0.45	0.48	0.45





- Before Starting Wastewater Treatment the nutrients availability: N> M> C=V
- After six month of Wastewater treatment processing: V> M> C >= N

Results From Paired T-Test for COD reduction

Compared Between	T	DF	P-Value	95% confidence interval	Sample mean difference
Vetiver Vs Phragmites	22.706	5	3.08e-06	35.35626 44.38374	39.87
Vetiver Vs Mixed	9.5919	5	0.0002087	21.04633 36.45700	28.75167
Phragmites Vs Mixed	-3.663	5	0.01455	-18.920748 -3.315918	-11.11833

One way ANOVA test of variance of COD reduction effeciency of Vetiver and Narkot with Growth Rate

Vetiver(*Chrosopogon zizanioides*)	Df	Sum Sq	Mean Sq	F value	Pr(>F)
(COD Red%)	1	16.1	16.06	0.112	0.754
Residual	4	571.9	142.99		

Narkot (*Phragmites karka*)	Df	Sum Sq	Mean Sq	F value	Pr(>F)
(COD Red%)	1	636.4	636.4	1.614	0.273
Residual	4	1577.0	394.2		

Relation Between Growth 1, Nutrient reduction in water 2 and Nurient enrichment in Soil 3

	Multiple Correlation			Partial Correlation		
	R1.23	R2.13	R3.12	R12.3	R13.2	R23.1
Total Phosphorus	0.755	0.484	0.908	0.791	0.605	0.586
Total N and NO3	0.9330	0.9452	0.659	0.926	0.464	0.609

• For Total Phosphorus, TP reduction in Water highly correlated to TP enriched in Soil ignoring the effect of Growth rate and Growth and TP reduction in wastewater highly correlated ignoring effect of Soil TP enrichment

•TP enrichment in soil highly depends on the Growth rate and TP reduction from water

•For NO3 and TN, Ignoring the effect of growth rate, TN and NO3 are highly correlated and also ignoring the effect of NO3 reduction in water sample, Growth rate and TN enrichment in soil are highly interrelated

•TN enrichment in Soil highly depends on the combined effect of Growth rate and NO3 reduction from water during treatment

Comparing the Results with Guideline Values

Parameters	Inlet	Vetiver Outlet	Narkot Outlet	Mixed Outlet	Control Outlet	Guideline Values		
						NWQG (2008) Irrigation	NWQG (2008) Aquatic life	CCME (1999) Agriculture
BOD5 (mg/l)	52.34	4.026	12.080	8.053	24.161		<15	
COD (mg/l)	693.3	133.33	448	320	405.33		<400	
CO_2 (mg/l)	140.8	30.8	61.1	52.50	101.2			1 to 10
Cl^- (mg/l)	233.2	44	110	92.4	171.6		Max 600	1 to 100
NO3-N (mg/l)	10.21	0.92	1.85	1.62	7.15			0.2 to 10
TP (mg/l)	24.51	3.064	11.032	9.806	16.548			
pH	5.7-7.7	3.5-7.5	5.3-7.8	6.8-7.7	6.8-7.4	6.8 to 8.5		7 to 9
Coliform/ 100ml	>300	33	115	82	>100	<1to1000		

- Reduced range of the pollutants concentration within the standard Guideline value by Vetiver treatment
- pH, Cl^- and Coliform count are within considerable limit according to Nepal's National Water Quality Guideline (2008)

Summary

- Growth rate greater in the Vetiver than Narkot
- Narkot showed dying and new growth continuously during Wastewater treatment
- As new plants played role in absorbing more nutrients compared to old ones, its efficiency was increased with increasing growth rate of new plants
- Mixed Pond performed better than Narkot in wastewater treatment
- Vetiver survived 100%,Wastewater treatment efficiency remained excellent everytime along its growth, Growth rate didn’t vary its efficiency

Conclusion

- Vetiver was found effective in wastewater treatment treating the wastewater to limits given by the Nepal's National water quality Guideline (2008) and Canadian Environmental Ministry water quality guideline (1999) in just six month after plantation
- Wastewater treated by Vetiver can be reused for irrigation, aquaculture, recreation and industrial purposes and has no harm to the aquatic lives and river ecosystem as being under limit of guideline values
- Phytoremediation in Constructed wetland- best and easy option for wastewater treatment at less invest of money, time and technology

Recommendation

- More practical, reliable and cheaper method of treating effluent before being passed into the river should be sought promoting reuse and recycle of wastewater
- Awareness activities about conserving water quality and quantity should be conducted in all parts of the country
- Strict laws and effluent standards should be enforced for the major contributors of wastewater like Industries, Hospitals, Hotels, Housings, Department malls etc.
- Guideline should be updated and maintained

Acknowledgement to All