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ASSESSMENT OF GROUNDWATER QUALITY FOR DRINKING AND HORTICULTURAL PURPOSES IN MONSOON SEASON AT VMRDA PARK, LUMBINI PARK, AND SHIVAJI PARK,VISAKHAPATNAM

Dr T.Usha Madhuri, Associate Professor, Department Of Civil Engineering Andhra University College Of Engineering, Visakhapatnam: **Email: umadhuri032@gmail.com**
Sri Vaishnavi Vinjarapu, MTech, Student Department Of Civil Engineering Andhra University College Of Engineering, Visakhapatnam

ABSTRACT:
Groundwater plays a crucial role in meeting the water demands of urban parks, both for drinking and horticultural purposes. This study focuses on evaluating the suitability of groundwater for these uses in VMRDA Park, Lumbini Park, and Shivaji Park of Visakhapatnam, a coastal city facing rapid urbanization. Groundwater samples were collected from these parks, and a comprehensive analysis was conducted to assess physical and chemical parameters, such as pH, electrical conductivity, total dissolved solids (TDS), hardness among others. The water quality was then evaluated against the Bureau of Indian Standards (BIS) guidelines for drinking water and irrigation and the Food and Agriculture Organization (FAO) standards for horticultural purpose.
The study highlights key areas of concern, including elevated levels of certain chemical contaminants that may pose risks to public health and plant growth. While some parks showed groundwater quality within acceptable limits for irrigation, others were identified as needing intervention to ensure safe usage. The findings emphasize the importance of continuous monitoring and the implementation of water treatment solutions to improve water quality for both human consumption and sustainable horticulture.
In conclusion, the study provides valuable insights for local authorities and park management teams to optimize water usage strategies and maintain groundwater resources.
Keywords : Groundwater, Irrigation, Drinking , Horticulture, Potability , Water Quality Index

INTRODUCTION:

Water quality plays a crucial role in maintaining the health and sustainability of urban ecosystems, particularly in public parks and green spaces where vegetation is cultivated for aesthetic, recreational, and environmental benefits. Visakhapatnam, a rapidly growing coastal city in Andhra Pradesh, relies heavily on available water resources for urban gardening and landscaping. The quality of water used in these gardens directly impacts plant health, soil conditions, and overall environmental sustainability and health safety of public..

OBJECTIVES OF THE STUDY :

The aim of this study is to assess the water quality used for gardening in the monsoon season in selected parks of Visakhapatnam, with a focus on understanding its impact on plant health and environmental sustainability and also to evaluate the potability of groundwater.
Objectives: 1**.** To do analysis for physico-chemical parameters of pH, TDS, EC, temperature, chlorides, sulphates, sodium, potassium, total hardness, calcium and magnesium
2.0 To evaluate the Water Quality Index and give rating for potability.
3.0 To compare the results with standards for irrigation.

METHODOLOGY:

The study is conducted in Visakhapatnam, a coastal city in Andhra Pradesh, known for its rapid urbanization and industrial growth. Located along the eastern coast of India, Visakhapatnam

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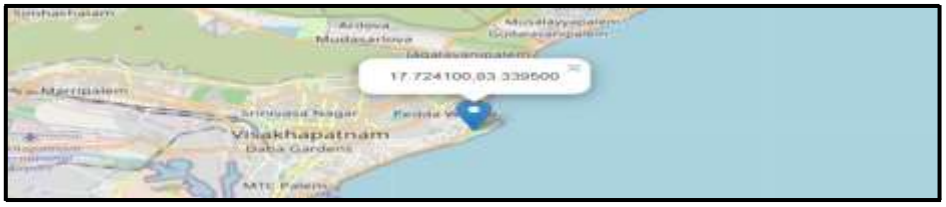

experiences a tropical wet and dry climate, which influences water availability and quality. Rainfall in the region primarily occurs during the southwest monsoon, typically between June and September, contributing to about 70% of the annual precipitation. This seasonal downpour plays a crucial role in replenishing groundwater levels and surface water bodies, which are vital for the parks under study.

Shivaji Park: A large public park located in the heart of the city, known for its greenery and recreational areas. This park uses groundwater and nearby municipal water sources for irrigation purposes, and the water quality here is critical for maintaining its vegetation. **Latitude:** 17° 44' 14.7336" N

Longitude: 83° 19' 52.3128"E

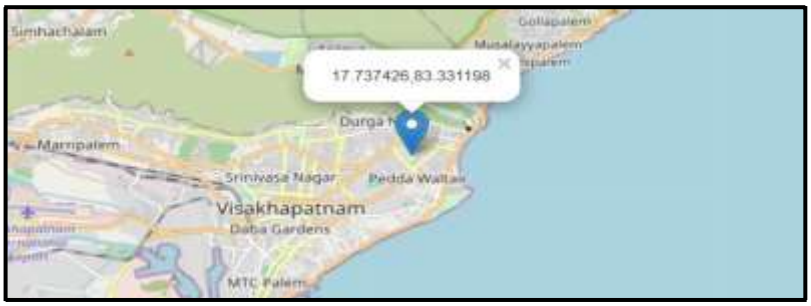

Figure1:LocationmapofShivajiPark

Lumbini Park: Situated near the Visakhapatnam Beach, this park is exposed to coastal weather conditions and has a mixture of natural and man-made water sources.

Latitude: 17° 44' 29.6844"N **Longitude:** 83° 20' 38.6628"E

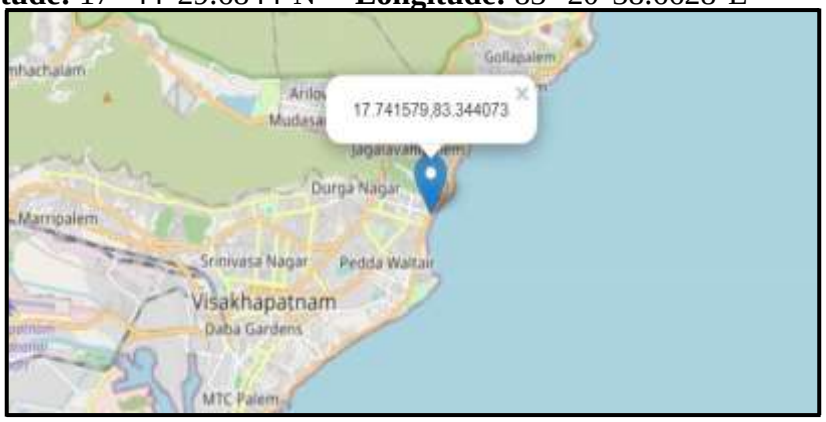

Figure2:LocationMapofLumbiniPark

VMRDA (Visakhapatnam Metropolitan Region Development Authority) Smart City Park: One of the largest parks in the region, VMRDA Park is located near the RK Beach. Earlier called VUDA Park, it serves as a recreational spot for residents and tourists alike. Water for gardening is sourced from the nearby urban supply, making it essential to monitor the quality to ensure the park's sustainable maintenance.

Latitude: 17° 43' 26.76"N **Longitude**: 83° 20' 22.2"E

Figure3:LocationmapofVMRDAPark

Sampling Schedule:

Water samples were collected **once a month** during the months of **June, July, and August**. This time

frame was chosen to capture the water quality during the monsoon season when changes in water sources due to rainfall are expected.

Sampling Volume , Handling and Storage:

Two 1-litre samples were collected each time from each sampling location to ensure sufficient water for testing various parameters and to minimize the possibility of errors due to sample variation.After collection, samples were carefully labeled with the date, location, and time of collection. Samples were then transported to the laboratory in clean, sterilized containers to prevent contamination, and testing was conducted within the same day to preserve sample integrity.

Water Quality Analysis: The collected water samples were analyzed for various physical and chemical parameters, including pH, TDS among others. Standard methods, such as those outlined by the American Public Health Association (APHA), were used to ensure accurate and reliable results.

Comparative Analysis: The results were compared against the standards set by the Bureau of Indian Standards (BIS) and the World Health Organization(WHO) to assess compliance and identify potential health risks. This comparison provides context to the findings and helps in understanding the implications for urban gardening practices.

PHYSICO-CHEMICAL ANALYSIS:

pH	: Using digital pH METER
Temperature	: Using Digital Thermometer
Electrical Conductivity (EC)	: Using Conductivity Meter
Total Dissolved Solids(TDS)	: TDS meter or gravimetric method.
Chlorides	: Titration Method (Mohr'sMethod)
Sulfates	: Gravimetric Method:
Sodium	: Flame Photometry:
Potassium	: Flame Photometry
Hardness	: Volumetric Analysis

DETERMINATION OF WATER QUALITY INDEX:

The Water Quality Index (WQI) is a mathematical tool used to simplify the representation of complex water quality data into a single number that can communicate the overall quality of water in a specific area or water body.

THE CALCULATION OF WQI WAS MADE USING WEIGHED ARITHMETIC INDEX METHOD (BROWN ET AL,1972) IN THE FOLLOWING STEPS:

1. Let there be water quality parameters and quality rating (qn) corresponding to nth parameter is a number reflecting relative value of its parameter in the polluted water with respect to its standard permissible value. On values are given by the relationship.

$$\mathbf{q_i=[(V_a-V_i)/(S_i-V_i)]}$$

V_a=Actual value of the i^{th} water quality parameter obtained from laboratory analysis.

V_n=ideal value of the i^{th} water quality parameter obtained from standard tables. q_i= Quality rating for the n water quality parameter

V_i=ideal value in most cases V_i=0 except in parameters where pHis7.0

2. Unit weight was calculated by a value inversely proportional to the recommended

$$\mathbf{W_i= k/S_i}$$

W_i=weightage factor

K = proportionality constant which is 1

S_i=Standard value of the ith water quality parameter

3. The overall water quality index was calculated by aggregating the quality rating with unit weight linearly

WQI = $\sum W_i q_i / \sum W_i$

PERCENT SODIUM AND SODIUM ADSORPTION RATIO (SAR):

Percent sodium:

It is a measure of sodium concentration in irrigation water relative to other major cations like calcium, magnesium, and potassium. Excessive sodium in water can lead to soil structure issues, such as reduced permeability and aeration, impacting plant growth.

$\%Na=\{\{[Na^+]\}/\{[Ca^{2+}]+[Mg^{2+}]+[Na^+]+[K^+]\}\}*100$

Sodium Absorption Ratio (SAR):

SAR assesses the potential risk of sodium accumulation in soil when using water for irrigation. High SAR values indicate a higher risk of sodium-induced soil degradation, reducing the soil's ability to drain properly and support plant growth.

$SAR=[Na^+]/\sqrt{\{([Ca^{2+}]+[Mg^{2+}])/2\}}$

STANDARDS CONSIDERED AS PART OF THE STUDY:

Table1:Drinking water specifications as per IS10500 (2012)

S.N	PARAMETER	REQUIREMENT (Acceptable Limit)	PERMISSIBLE LIMIT (In the absence of alternate source)
1	**pH**	6.5 - 8.5	No relaxation
2	**TDS** (mg/L), Max	500	2000
3	**Chloride**(as Cl) (mg/L), Max	250	1000
4	**Sulphate**(asSO_4) (mg/L), Max	200	400
5	**Total hardness** (as $CaCO_3$) (mg/L), Max	200	600
6	**Calcium**(as Ca) (mg/l), Max	75	200
7	**Magnesium**(as Mg) (mg/L), Max	30	100

(A) IS11624(1986):GUIDELINES FOR THE QUALITY OF IRRIGATION WATER:

This Indian Standard was adopted by the Indian Standards Institution on 27 March 1986,after the draft finalized by the Irrigation Equipment and Systems Sectional Committee had been approved by the Agricultural and Food Products Division Council. To evaluate the quality of irrigation water, this standard has been prepared as a guideline for advisory purposes.

Table2:Water Quality Rating as per IS:11624(1986)

S. NO.	CLASS	Range of EC (µS/cm)	RangeofSAR(√millimole/litre)
1	**LOW**	<1500	<10
2	**MEDIUM**	1500 - 3000	Oct-18
3	**HIGH**	3000 - 6000	18 - 26
4	**VERYHIGH**	>6000	>26

(B) WHO GUIDELINES FOR WATER USED FOR IRRIGATION:

The World Health Organization (WHO) does not have a single, specific document exclusively titled for irrigation water standards. Instead, WHO provides guidelines related to irrigation in broader publications.

Table3:WHO Guidelines for suitability of water for irrigation

CLASS OF WATER	EC (µmho)	TDS (ppm)	Sulphates (ppm)	Chlorides (ppm)	%Sodium (-)	SUITABILITYFOR IRRIGATION
I	0-750	0-700	0-192	0-142	0-60	Excellent to good for irrigation
II	750-2250	700-2000	192-480	142-355	60-75	Good to injurious, conditionally suitable
III	>2250	>2000	>480	>355	>75	Unfit for irrigation

Table4: Suitability of water for irrigation with different values of SAR

SAR	SUITABILITYFORIRRIGATION
0-10	Suitable for all types of crops and all types of soils, except for those which are highly sensitive to sodium
10-18	Suitable for coarse textured or organic soil with good permeability. Relatively unsuitable in fine
18-26	Harmful for almost all types of soils. Require good drainage, high leaching and gypsum addition
>26	Unsuitable for irrigation

(C) FAO STANDARDS FOR IRRIGATION WATER (FAO,1970)

The Food and Agriculture Organization (FAO) Irrigation and Drainage Paper No. 10: Water Quality Criteria (1970) outlines guidelines for assessing water quality for agricultural use. It establishes criteria for various parameters to ensure water suitability for irrigation, thereby supporting sustainable crop production and soil health.

Table5:FAO standards for irrigation water

PARAMETER	UNIT	USUAL RANGE IN IRRIGATIONWATER
pH	_	6.0 - 8.5
EC	dS/m	0 - 3

TDS	mg/L	0 - 2000
Chloride	meq/L	0 - 30
Sulphate	meq/L	0 - 20
Sodium	meq/L	0 - 40
Calcium	meq/L	0 - 20
Magnesium	meq/L	0 - 5
SAR	meq/L	0 - 15

(D) WATER QUALITY INDEX (WQI) RATINGS

Table6: Rating water quality based on water quality index(weighted arithmetic index method)

S.NO.	WATERQUALITYINDEX(WQI)	STATUS
1	0-25	Excellent
2	26-50	Good
3	51-75	Poor
4	76-100	Very Poor
5	>100	Unsuitable For Drinking (U.F.D.)

RESULTS OF THE PHYSICO-CHEMICAL ANALYSIS OF GROUNDWATER

Table7:Results of the physico-chemical analysis of the samples

PARAMETER		pH	Temp	EC	TDS	Cl−	SO_4^{2-}	Na+	K+	TH	Ca2+	Mg2+
PARK	MONTH	N/A	(°C)	(µS/cmm)	(ppm)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(ppm)	(mg/L)	(mg/L)
VP	JUNE	8.8	14.3	1454	727	481.1	133.1	55	1	186	79.3	11.4
	JULY	8.2	14.2	1492	701	501.1	143.1	56	1	232	89.7	16.1
	AUG	7.2	14.1	1510	679	501.1	148.5	58	2	280	107.3	17.7
	JUNE	8.3	15.7	1426	713	621.4	87.2	59	22	194	75.7	8.2

LP	**JULY**	8	15.5	1504	815	641.5	96.1	61	21	208	90.5	8.5
	AUG	7.5	15.6	1567	931	651.4	101.6	62	21	231	91.3	9.7
SP	**JUNE**	7.1	16.1	1214	637	249.5	146.1	40	1	250	108.5	9.9
	JULY	7	15.8	1294	652	279.5	152.1	41	2	232	100.5	9.2
	AUG	6.8	15.7	1358	679	319.4	157.2	42	2	220	96.1	9.7

Table 8: (WQI) RATINGS FOR POTABILITY:

PARK	MONTH	WQI	STATUS
VMRDA PARK	JUNE	100.8	Unsuitable For Drinking (U.F.D.)
	JULY	79.6	Very Poor
	AUGUST	40.8	Good
LUMBINI PARK	JUNE	77.6	Very Poor
	JULY	66.6	Poor
	AUGUST	47.2	Good
SHIVAJI PARK	JUNE	28.8	Good
	JULY	23.6	Excellent
	AUGUST	49.1	Good

ASSESSMENT OF THE SUITABILITY OF WATER TO HORTICULTURE:
(A)COMPARISON OF RESULTS WITH IS:11624(1986)
Table 9 :Determination of Water Quality Rating based on the Total Salt Concentration and Sodium Adsorption Ratio (SAR)

PARK	MONTH	EC	CLASS	SAR	CLASS
VMRDA PARK	**JUNE**	1454	**Low**	8.198	**Low**
	JULY	1492	**Low**	7.728	**Low**
	AUGUST	1510	**Medium**	7.336	**Low**

LUMBINI PARK	**JUNE**	1426	**Low**	9.158	**Low**
	JULY	1504	**Medium**	8.714	**Low**
	AUGUST	1567	**Medium**	8.768	**Low**
SHIVAJIPARK	**JUNE**	1214	**Low**	5.207	**Low**
	JULY	1294	**Low**	5.528	**Low**
	AUGUST	1358	**Low**	5.796	**Low**

The class is expressed in relation To the hazardous effects of the total salt concentration and sodium adsorption ratio.

(B)COMPARISON OF RESULTS WITH WHO STANDARDS FORIRRIGATION WATER:

Table10:Determination of class of water in suitability to irrigation

PARAMETER		**EC**	**CLASS**	**TDS**	**CLASS**	**Chlorides**	**CLASS**	**Sulphates**	**CLASS**
PARK	**MONTH**	**(µS/cm)**		**(ppm)**		**(ppm)**		**(ppm)**	
VP	JUNE	1454	**Class II**	727	**Class II**	481.1	**Class III**	133.1	**Class I**
	JULY	1492		701	**Class II**	501.1		143.1	
	AUG	1510		679	**Class I**	501.1		148.5	
LP	JUNE	1426		713	**Class II**	621.4	**Class III**	87.2	
	JULY	1504		815		641.5		96.1	
	AUG	1567		931		651.4		101.6	
SP	JUNE	1214		637	**Class I**	249.5	**Class III**	146.1	
	JULY	1294		652		279.5		152.1	
	AUG	1358		679		319.4		157.2	

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(C) COMPARISON OF RESULTS WITH FAO STANDARDS FOR IRRIGATION WATER (FAO, 1970)

Table11:Comparison of results with FAO standards

PARAMETER	PARK	VP			LP			SP		
	MONTH	JUN	JUL	AUG	JUN	JUL	AUG	JUN	JUL	AUG
pH		NOT IN UR	WITHIN USUAL RANGE							
EC	dS/cm	WITHIN USUAL RANGE								
TDS	mg/L	WITHIN USUAL RANGE								
Cl-	meq/L	WITHIN USUAL RANGE								
SO_4^{2-}	meq/L	WITHIN USUAL RANGE								
Na+	meq/L	WITHIN USUAL RANGE								
Ca2+	meq/L	WITHIN USUAL RANGE								
Mg2+	meq/L	WITHIN USUAL RANGE								
SAR	meq/L	WITHIN USUAL RANGE								

(C) DETERMINATION OF PERCENT SODIUM AND SODIUM ADSORPTION RATIO

Table12:PercentSodium, SAR values and remarks

PARK	MONTH	% Na	STATUS	REMARKS	SAR	REMARKS
VMRDA PARK	JUNE	37.67	Class I	Excellent to good for irrigation	8.198	Suitable for all types of crops and all types of soils, except for those crops which are highly sensitive to sodium
	JULY	34.56	Class I		7.728	
	AUG	31.35	Class I		7.336	
LUMBINI PARK	JUNE	35.97	Class I		9.158	
	JULY	33.88	Class I		8.714	
	AUG	33.87	Class I		8.768	
SHIVAJI PARK	JUNE	25.15	Class I		5.207	
	JULY	26.79	Class I		5.528	
	AUG	28.18	Class I		5.796	

CONCLUSIONS :

1. pH

VMRDA Park: The Ph in June(8.8)is highly alkaline, which can inhibit the availability of essential

nutrients for plants. By August, the pH drops to 7.2, making it more suitable for a wider variety of plants.
Lumbini Park: The pH values indicate that while June and July have slightly alkaline conditions, August reaches pHof7.5, which is more favorable for most garden plants.
Shivaji Park: The pH values indicate the stability in the water samples, where they are almost around the neutral range, indicating suitability to horticulture.

Total Dissolved Solids(TDS) :
VMRDA Park: The declining TDS levels suggest an improvement in water quality, making it more suitable for plant growth as the concentration of dissolved salts decreases.
Lumbini Park: The increasing TDS level suggest a decline in water quality, making it more suitable for plant growth as the concentration of dissolved salts decreases.
Shivaji Park: The TDS levels remain relatively low among all three parks, suggesting that the water quality is generally favorable for most garden plants.

CHLORIDES:
VMRDA Park: It showed a slight increase in chloride concentrations over the monsoon months. This increase could be due to potential contamination sources.
LumbiniPark: Whileslightincreaseisobservedacrossthemonsoonmonths,thevaluesare highest among the three parks. The increase is consistent with the trends observed in VMRDA Park, reflecting potential changes in environmental factors or human activities influencing chloride concentrations.
ShivajiPark: Thisparkexhibitedthelowestvaluesoverall.Thelowerlevelsofchlorides indicate relatively better water quality compared to the other two parks, which might be attributed to lower anthropogenic impacts or better management practices.

SODIUM:
VMRDA Park: Sodium concentrations exhibited a slight increase from55mg/L in June to 58 mg/L in August. This gradual rise suggests either an increasing source of sodium or changes in water conditions that enhance sodium solubility and availability.
Lumbini Park: Sodium levels increased more significantly, starting at 59 mg/L in June and rising to 62mg/L in August. The consistent increase over the three months indicates potential
Contributions from urban runoff, irrigation practices, or local activities that introduce sodium into the water system.
Shivaji Park: Sodium concentrations were notably lower than in the other parks, at 40 mg/L in June and increasing to 42 mg/L in August. This gradual increase may reflect the park's lower exposure to sodium sources compared to the other parks, which could be beneficial for maintaining a healthier ecosystem.

POTASSIUM:
VMRDA Park: Potassium concentrations remained relatively low, starting at1mg/L in June and slightly increasing to 2 mg/L in August. This indicates minimal potassium presence, suggesting that the park's water quality is less influenced by sources rich in potassium.
Lumbini Park: In contrast, Lumbini Park exhibited significantly higher potassium levels, with 22 mg/L in June decreasing to 21 mg/L in both July and August. This indicates a relatively stable but elevated level of potassium, likely influenced by urban runoff, soil amendments, or local vegetation contributing potassium to the water body.
Shivaji Park: Similar to VMRDA Park, potassium levels remained low,beginningat1mg/L in June and increasing to 2 mg/L in August. This suggests that Shivaji Park, like VMRDA Park, is less affected by

potassium sources, maintaining lower concentrations overall.

TOTAL HARDNESS:
VMRDA Park: For VMRDA Park, there is a noticeable increase in hardness from Junet o August, reaching 280 mg/L in August. This gradual rise may indicate increased mineral content, likely due to factors such as evaporation during the summer months, which concentrates dissolved ions, or runoff from surrounding areas that contributes
hardness-causing minerals.
Lumbini Park: Lumbini Park shows a similar but more moderate increase, with total hardness risingfrom194mg/L in June to231mg/L in August. The consistent yet gradual rise suggests fewer extreme influences compared to VMRDA Park, potentially due to varying local factors like land use or irrigation practices.
Shivaji Park: Shivaji Park exhibits a slight decline in hardness from June(250mg/L)to August(220mg/L),peaking in June. The decrease might be due to factors like increased water input from rains diluting hardness or less mineral influx during specific periods.

WATER QUALITY INDEX(WQI)FOR POTABILITY:
VMRDA Park: The Water Quality Index (WQI) in VMRDA Park improves from 100.8 in June to 40.8 in August, indicating a significant enhancement in water suitability over time.
Lumbini Park: Lumbini Park also shows improvement, with WQI decreasing from 77.6 in June to 47.2 in August, reflecting a steady increase in good water quality.
Shivaji Park: Shivaji Park has the best water quality among the three, with a low WQI in June (28.8) that improves slightly by July, then increases to 49.1 in August, suggesting slight seasonal fluctuations but overall better suitability compared to the other parks.

PERCENT SODIUM(%NA)::
VMRDA Park: The percent sodium in VMRDA Park shows a decreasing trend from37.67% in June to 31.35% in August, indicating an improvement in water quality, as lower sodium percentages generally enhance suitability for irrigation.
Lumbini Park: Lumbini Park's sodium percentage decreases slightly from 35.97 %in June to 33.87% by August, showing a minor improvement in water quality with respect to sodium content.
Shivaji Park: Shivaji Park has the lowest sodium percentages among the three parks, with a gradual increase from 25.15% in June to 28.18% in August. Despite the slight rise, it maintains the best sodium levels for irrigation suitability.

SODIUM ADSORPTION RATIO (SAR):
VMRDA Park The sodium adsorption Ratio (SAR)in VMRD A Parkdecreasesfrom8.198 in June to 7.336 in August, suggesting an improvement in water quality for irrigation, as lower SAR values reduce the risk of soil sodicity.
Lumbini Park: In Lumbini Park, SAR values decrease from 9.158 in June to 8.714 in July, but slightly increase to 8.768 in August. This slight fluctuation indicates relatively stable but moderate SAR levels, with limited improvement in irrigation suitability.
Shivaji Park: Shivaji Park consistently has the lowest SAR values among the three parks, ranging from 5.207 in June to5.796 in August. These low SAR values indicate that the water is most suitable for irrigation, with minimal risk of soil sodicity.

RATING WITH RESPECT TO WAWQI FOR POTABILITY:
Based on the WAWQI values obtained,

Maximum WQI: 100.8 (Unfit for Drinking), obtained in June at VMRDA Park
Minimum WQI:23.6 (Excellent), obtained in July at Shivaji Park
AverageWQIatVMRDAPark:73.73(Poor) **Average WQI at Lumbini Park**: 63.8 (Poor) **Average WQI at Shivaji Park:** 33.8 (Good)

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