


**STUDY ON PHYSICOCHEMICAL PARAMETERS AND  
BENTHIC MACRO INVERTEBRATES OF PANIMUHAN  
STREAM OF SHIVAPURI NATIONAL PARK**



**A Dissertation  
Submitted in partial fulfillment  
For Master's Degree in Zoology with specialized paper  
Ecology**



**by  
Aradhana Rai**



**Central Department of Zoology  
Institute of Science and Technology  
Tribhuvan University  
Kirtipur  
Kathmandu  
Nepal  
2008**

Date: .....

## LETTER OF RECOMMENDATION

It is recommended that Miss **Aradhana Rai** has completed her dissertation work entitled “**Study on physicochemical parameters and benthic macro invertebrates of Panimuhan stream of Shivapuri National Park**” under my supervision. This is the candidate’s original work, which brings out useful findings in the concerned field. To the best of my knowledge, this dissertation has not been submitted for any other degree in any institution. Hence, I recommend this dissertation to be accepted for the partial fulfillment of requirement for Master’s degree of Science in Zoology (Ecology).

---

Supervisor  
Dr. Mukesh Kumar Chalise  
Associate Professor  
Central Department of Zoology  
Tribhuvan University  
Kirtipur, Kathmandu  
Nepal

Date:.....

## LETTER OF RECOMMENDATION

It is recommended that Miss **Aradhana Rai** has completed her dissertation work entitled “**Study on physicochemical parameters and benthic macro invertebrates of Panimuhan stream of Shivapuri National Park**” under my supervision. This is the candidate’s original work, which brings out useful findings in the concerned field. To the best of my knowledge, this dissertation has not been submitted for any other degree in any institution. Hence, I recommend this dissertation to be accepted for the partial fulfillment of requirement for Master’s degree of Science in Zoology (Ecology).

---

Co-Supervisor

Dr. Kanti Shrestha

Senior Scientific Officer

Natural Products Research Laboratory

## LETTER OF APPROVAL

On the recommendation of Supervisor Dr. Mukesh Kumar Chalise, Associate Professor, Central Department of Zoology, Tribhuvan University and Co-supervisor Dr. Kanti Shrestha, Senior Scientific Officer, Natural Products Research Laboratory, Nepal Academy of Science and Technology, the dissertation work entitled **“Study on physicochemical parameters and benthic macro invertebrates of Panimuhan stream of Shivapuri National Park”** submitted by Miss **Aradhana Rai** has been approved for the examination.

---

Prof. Dr. Vasanta Kumar Thapa  
Department Head  
Central Department of Zoology  
Tribhuvan University  
Kirtipur, Kathmandu  
Nepal

Date: .....

## LETTER OF ACCEPTANCE

The dissertation work entitled “**Study on physicochemical parameters and benthic macro invertebrates of Panimuhan stream of Shivapuri National Park**” submitted by Miss **Aradhana Rai** has been accepted as the partial fulfillment of the requirement for Master's Degree of Science in Zoology with “Ecology” as special paper.

### EXPERT COMMITTEE

---

Prof. Dr. Vasanta Kumar Thapa  
Department Head  
Central Department of Zoology  
Tribhuvan University  
Kirtipur, Kathmandu

---

Supervisor  
Mukesh Kumar Chalise Ph.D.  
Associate Professor  
Central Department of Zoology  
Tribhuvan, University  
Kirtipur, Kathmandu

---

Co-Supervisor  
Dr. Kanti Shrestha  
Senior Scientific Officer  
Natural Products Research Laboratory  
Nepal Academy of Science and Technology  
Khumaltar, Lalitpur  
Nepal

---

External Examiner

---

Internal Examiner

## ACKNOWLEDGEMENTS

This research work has been accomplished by the kind support, valuable suggestions and constant encouragement from many individuals.

I wish to express my sincere gratitude and respect to my supervisor Associated Prof. Dr. Mukesh Kumar Chalise for his noble guidance and well supervision. I am highly indebted to my supervisor Dr. Kanti Shrestha, Senior Scientific Officer of Natural Products Research Laboratory of Nepal Academy of Science and Technology (NAST) for her constant guidance, support, encouragement and lab facilities.

It is my pleasure to express my deepest gratitude to Prof. Dr. Vasanta Kumar Thapa, Head of the Central Department of Zoology for his kind co-operation in providing the essential facilities required during study period. My special thanks go to Mr. Prem Bahadur Budha sir for helping me during the identification of species. I am grateful to all my teaching, administration and supportive staffs of Central Department of Zoology for their valuable support, guidance and help.

I am very much thankful to Department of National Parks and Wildlife Conservation (DNPWC) and Shivapuri National Park (ShNP) for providing me permission for my research work, library other necessary information. Also my thank goes to WWF and ICIMOD for providing necessary information and library facilities. I am extremely grateful to Nepal Academy of Science and Technology (NAST) for providing necessary lab and library facilities.

I sincerely express my heartfelt gratitude to my parents and family for their love, inspiration and support. Special thanks go to my friends Bharati, Sampa, Sarita, Suchitra, Kamal I also thankful to Poonam, Pujya, Trishna, Suman, Tista madam and Natural Product's Research Laboratory family for their continuous help and moral support. Finally, I would like to ask for forgiveness and thanks to all whom I forget to acknowledge to despite their contribution to this research.

Aradhana Rai  
Roll no. 1156  
T.U. Regd. No. 5-2-37-716-2000  
Batch No. 2061/062

## ABSTRACT

Shivapuri National Park (ShNP) reservoir is a major source of water for Kathmandu Valley providing 35.6 million liter per day. In the present study period of six months from July-December physicochemical parameters like velocity of water, pH, temperature, total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), free carbon dioxide (CO<sub>2</sub>), total alkalinity and total hardness (calcium and magnesium) were assessed and furthermore benthic macro invertebrates were also explored. Among the three sites, the first and second site were inside the ShNP at altitude of 1700 m and 1610 m respectively and the third site was at altitude of 1500 m outside the ShNP. Water velocity and temperature was conducted at the sites whereas other chemical parameters were performed at Natural Products Research Laboratory of Nepal Academy of Science and Technology (NAST). The current of water was measured by surface float method and the highest velocity was 1.0 m/sec at site 2 in July and the maximum temperature was 21 °C at site 3 in August. The pH 7.5 was found at sites 2 in July. TS was determined by residue left after evaporating unfiltered sample water and found value of 1900 mg/l at site 2, TDS was determined by residue left after evaporating filter sample and found average value of 1500 mg/l at site 2 and 3 and TSS determined by difference between the TS and TDS and the average was 400 mg/l at site 2 and 3. Similarly the maximum DO concentration was 9.32 mg/l at site 2 in November. The highest free CO<sub>2</sub> concentration was 13.2 mg/l at site 1 in July. The maximum total alkalinity was 70 mg/l at site 2 and 3, the highest total hardness was 34 mg/l at site 3 in December and finally the highest concentration of calcium and magnesium were 10.42 mg/l at and 2.43 mg/ l respectively at site 3. Similarly, the benthic macro invertebrates of Panimuhan stream were identified by using sieve of 500 μ and 20×20cm size quadrat and 54 samples were collected and were preserved in 80% of alcohol. Altogether 32 taxa belonging to 9 orders, 29 families and 28 genera of benthic-macro invertebrates were reported. Among them order Ephemeroptera (28.6%) was highly dominant in all the sites followed by diversified Tricoptera (25.5%), and Placoptera (14.4%). Diptera (13.3%) was followed by Tricladida (6%), Odonata (4.4%), Stylommatophora (2.8%), Neuroptera (2.5) and finally Coleoptera (2.1%) which was least dominant group. And site 3 comprised the higher number of species i.e. 37.05% ( $\bar{D} = 1.75$ ) and the values of evenness (e) were 0.52, 0.40 and 0.51 at sites 1, 2 and 3 respectively demonstrated that the species were distributed in similar pattern in all the three sites. During the study period site 3 was found mid pollutant due to domestic wastage where people should be aware of negative impact of natural river water pollution. However, overall physicochemical components and abundance of benthic macro invertebrates depict the non pollutant condition of the Panimuhan stream of Shivapuri National Park in the year 2007.

# CONTENTS

	<b>Pages</b>
Letter of Recommendation	i
Letter of Recommendation	ii
<b>Letter of Approval</b>	<b>iii</b>
<b>Letter of Acceptance</b>	<b>iv</b>
<b>Contents</b>	<b>v</b>
<b>List of Figures</b>	<b>ix</b>
<b>List of Tables</b>	<b>x</b>
<b>Abbreviations and Acronyms</b>	<b>xii</b>
<b>Acknowledgements</b>	<b>xiv</b>
<b>Abstract</b>	<b>xv</b>
<b>1. INTRODUCTION</b>	
1.1. General Background	1
<b>2. LITERATURE REVIEW</b>	
2.1. Water Quality	4
2.2. Water Pollution	7
2.3. Study reveals physicochemical parameters	7
2.4. Study reveals biological parameters	9
<b>3. METHODS AND METHODOLOGY</b>	
3.1. Study Area	12
3.1.1. River System	12
3.2. Site Selection	14
3.3. Rationale of the study	15
3.4. Objectives	17
3.5. Physical Parameters of water	18
3.5.1. Velocity (m/sec)	18
3.5.2. Temperature (°C)	18
3.5.3. Hydrogen ion concentration (pH)	18
3.5.4. Total solids (TS)	18
3.5.5. Total dissolved solids (TDS)	19
3.5.6. Total suspended solids (TSS)	19
3.6. Chemical Parameters of water	19
3.6.1. Dissolved oxygen (D.O.)	19
3.6.2. Free Carbon dioxide (mg/l):	20
3.6.3. Total alkalinity (mg/l)	20



3.6.4. Total Hardness	21
3.6.5. Calcium Hardness	21
3.6.6. Magnesium Hardness	21
3.7. Sampling of benthic macro-invertebrates	21
3.8. Statistical Analysis	22
3.8.1. Chi-Square ( $\chi^2$ ) test (variance to mean ratio):	22
3.8.2. Variance ( $S^2$ )	22
3.8.3. Arithmetic Mean ( $\bar{X}$ )	22
3.8.4. Correlation Coefficient (r)	23
3.8.5. Species Diversity ( $\bar{D}$ )	23
3.8.6. Evenness index (e)	23

#### 4. RESULTS

4.1. Physicochemical Parameters of water	24
4.1.1. Water velocity (m/sec)	25
4.1.2. Temperature ( $^{\circ}\text{C}$ )	25
4.1.3. Hydrogen ion concentration (pH)	26
4.1.4. Total solids (TS) mg/l	27
4.1.5. Total dissolved solids (TDS) mg/l	28
4.1.6. Total suspended solids (TSS) mg/l	29
4.1.7. Dissolved oxygen (D.O.)mg/l	30
4.1.8. Free carbon dioxide ( $\text{CO}_2$ ) mg/l	31
4.1.9. Total alkalinity mg/l	32
4.1.10. Total hardness mg/l	33
4.1.11. Calcium (Ca) hardness mg/l	34
4.1.12. Magnesium (Mg) hardness mg/l	35
4.2. Biological Parameters of water	36
4.2.1. Benthic Macro-invertebrates reported over the period of six months	36
4.2.2. Monthly fluctuation in mean values of benthic macro invertebrates	39
4.2.3. The average percentages distribution of each representative species	40
4.3. Species diversity of benthic-macro invertebrates	41
4.4. Correlation between Physicochemical Parameters and Benthic- macro fauna at sampling Sites	41
4.5. The monthly fluctuation in abundance of benthic macro invertebrates	42
4.6. Analysis of Statistical Tools	48

<b>5. DISCUSSION</b>	57
<b>6. CONCLUSIONS</b>	64
<b>7. RECOMMENDATIONS</b>	65
<b>8. REFERENCES AND BIBLIOGRAPHY</b>	66
<b>9. APPENDICES 1</b>	

## **APPENDICE 2**

### Order 1: Tricladida

Plate 1: *Dugesia* sp

### Order 2: Ephemeroptera

Plate 2: *Epeorus* sp

Plate 3: *Heptagenia* sp

Plate 4: Anal filaments of *Heptagenia* sp

Plate 5: Abdominal gills of *Heptagenia* sp

Plate 6: *Baetis* sp

Plate 7: *Caenis* sp

Plate 8: Caudal filament of *Caenis* sp

Plate 9: *Serratella* sp

Plate 10: Anal filament of *Serratella* sp

Plate 11: *Ephemerella* sp

### Order 3: Odonata

Plate 12: *Cephalaeschna* sp

Plate 13: Prementum of *Cephalaeschna* sp

Plate 14: *Ophiogomphus* sp

Plate 15: Prementum of *Ophiogomphus* sp

Plate 16: *Anotogaster* sp

Plate 17: Palp dentation of *Anotogaster* sp

Plate 18: *Megalestes* sp

Plate 19: Anal gills of *Megalestes* sp

### Order 4: Placoptera

Plate 20: *Neoperla* sp

Plate 21: *Protonemura* sp

Plate 22: Anal filament

Showing swollen segment

Plate 23: *Amphinemoura* sp

Plate 24: *Peltoperla* sp

### Order 5: Neuroptera

Plate 25: *Corydalus* sp

Plate 26: Psephenidae larva (Dorsal view)

Plate 27: Psephenidae larva (Ventral view)

- Plate 28: Gyrinidae larva
- Plate 29: Elmidae (Adult)
- Plate 30: Elmidae (larva)

Order 6: Tricoptera

- Plate 31: Case of *Glossosoma* sp
- Plate 32: *Hydropsyche* sp
- Plate 33: *Stenopsyche* sp
- Plate 34: Hydroptilidae
- Plate 35: *Nectopsyche* sp
- Plate 36: *Lepidostoma* sp
- Plate 37: Case of *Lepidostoma* sp
- Plate 38: *Rhyacophila* sp
- Plate 39: *Chimarra* sp

Order 7: Diptera

- Plate 40: *Simulium* sp
- Plate 41: Pupae of *Simulium* sp
- Plate 42: *Chironomus* sp
- Plate 43: *Antocha* sp
- Plate 44: *Atherix* sp

Order 8: Stylommatophora

- Plate 45: *Physa* sp

Study Sites

- Plate 46: Site 1
- Plate 47: Site 2
- Plate 48: Site 3
- Plate 49: Water Reservoir of Panimuhan
- Plate 50: Solid wastes disposed at site 3
- Plate 51: Children swimming at Site 3
- Plate 52: Solid wastes near site 3
- Plate 53: Sorting benthic macro fauna
- Plate 54: Trapping Dissolved oxygen
- Plate 55: Experiment in Lab

## LIST OF FIGURES

Figure 1:	Location of Shivapuri National Park	13
Figure 2:	Shivapuri National Park	13
Figure 3:	Study sites at Panimuhan stream	14
Figure 4:	Variation in velocity of water during the study period of six months	25
Figure 5:	Variation in temperature of water during the study period of six months	26
Figure 6:	Variation in pH of water during the study period of six months	27
Figure 7:	Variation in total solids of water during the study period of six months	28
Figure 8:	Variation in total dissolved solids of water during the study period of six months	29
Figure 9:	Variation in total suspended solids of water during the study period of six months	30
Figure 10:	Variation in dissolved oxygen of water during the study period of six months	31
Figure 11:	Variation in free carbon dioxide of water during the study period of six months	32
Figure 12:	Variation in total alkalinity of water during the study period of six months	33
Figure 13:	Variation in total hardness of water during the study period of six months	34
Figure 14:	Variation in calcium hardness of water during the study period of six months	35
Figure 15:	Variation in magnesium hardness of water during the study period of six months	36
Figure 16:	The percentage of benthic macro invertebrates in 2007	41

## LIST OF TABLES

Table 1:	Average fluctuation on physicochemical parameters of three sites during the study period of six months.	24
Table 2:	Total numbers of benthic macro-fauna collected from July - December 2007	39
Table 3:	Monthly fluctuation in mean values of benthic-fauna distribution (no. /m <sup>2</sup> )	40
Table 4:	Shannon – Wiener Diversity Index for benthic-macro invertebrates	41
Table 5:	Correlation Coefficient between variables and Benthic-macro fauna	42
Table 6:	Monthly variations in the abundance of Tricladida (no. /m <sup>2</sup> ) at all three sites	43
Table 7:	Monthly variations in the abundance of Ephemeroptera (no. /m <sup>2</sup> ) at all three sites	43
Table 8:	Monthly variations in the abundance of Odonata (no. /m <sup>2</sup> ) at all three sites	44
Table 9:	Monthly variations in the abundance of Placoptera (no. /m <sup>2</sup> ) at all three sites	44
Table 10:	Monthly variations in the abundance of Neuroptera (no. /m <sup>2</sup> ) at all three sites	45
Table 11:	Monthly variations in the abundance of Coleoptera (no. /m <sup>2</sup> ) at all three sites	45
Table 12:	Monthly variations in the abundance of Tricoptera (no. /m <sup>2</sup> ) at all three sites	46
Table 13:	Monthly variations in the abundance of Diptera (no. /m <sup>2</sup> ) at all three sites	47
Table 14:	Monthly variations in the abundance of Stylommatophora (no. /m <sup>2</sup> ) at all three sites	47
Table 15:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for order Tricladida at different sites	48
Table 16:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for order Ephemeroptera at different sites	49
Table 17:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for order Placoptera at different sites	50
Table 18:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for Tricoptera at different sites	51

Table 19:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for order Odonata at different sites	52
Table 20:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for Coleoptera at different sites	53
Table 21:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for order Diptera at different sites	54
Table 22:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for order Neuroptera at different sites	55
Table 23:	Value of Arithmetic mean ( $\bar{X}$ ), Variance ( $S^2$ ), Chi-square ( $\chi^2$ ) with significance level (P) for order Stenommatophora	56
Table 24:	Monthly fluctuation on physicochemical parameters of site 1 during the study period of six months	74
Table 25:	Monthly fluctuations on physicochemical parameters of site 2 during the study period of six months	75
Table 26:	Monthly fluctuations on physicochemical parameters of site 3 during the study period of six months	76

## ABBREVIATIONS AND ACRONYMS

Aug.	August
BOD	Biological Oxygen Demand
CBS	Central Bureau of Statistics
Ca	Calcium
CO <sub>2</sub>	Carbon dioxide
CaCO <sub>3</sub>	Calcium carbonate
$\bar{D}$	Species Diversity
Dec.	December
DNPWC	Department of National Park and Wildlife Conservation
DO	Dissolved oxygen
EDTA	Ethylenediamine tetraacetic acid
ENPHO	Environment and Public Health Organization
FAO	Food and Agriculture Organization
GIS	Global Information System
HKH	Hindu Kush-Himalaya
HMG	His Majesty's Government
H <sub>2</sub> SO <sub>4</sub>	Sulphuric acid
HCl	Hydrochloric acid
i.e.	That is
Jul.	July
Km	Kilometer
KI	Potassium iodide
L	Liter
m	Meter
mg	Milligram
ml	Millilitre
MnSO <sub>4</sub>	Manganous sulphate
Mg	Magnesium
M <sup>2</sup>	Meter square

n	Number of samples/number of species
NAST	Nepal Academy of Science and Technology
NaOH	Sodium hydroxide
Nov.	November
RONAST	Royal Nepal Academy of Science and Technology
r	Correlation Coefficient
RHP	River Health Program
Oct.	October
S	Standard deviation
S <sup>2</sup>	Variance
S.E.	Standard Error
Sec	Second
Sept.	September
ShNP	Shivapuri National Park
sp	Species
TA	Total alkalinity
TDS	Total dissolved solids
TS	Total solids
TSS	Total suspend solids
V	Volume
VDC	Village Development Committee
W.H.O	World Health Organization
WWF	World Wide Fund
$\bar{X}$	Arithmetic mean
$\chi^2$	Chi-Square
	Summation