Dedicated to my Family

Declaration

I declare that the thesis entitled "**Genotoxic effects of fungicide(s) in the fish *Pethia conchonius* (Hamilton, 1822) from river Teesta of northern region of West Bengal"** has been prepared by me under the guidance of **Professor Min Bahadur**, **Department of Zoology, University of North Bengal**. No part of this thesis has previously formed the basis for the award of any degree or fellowship.

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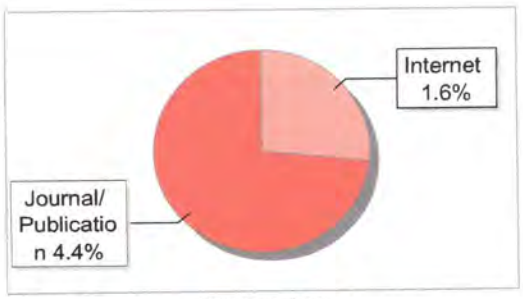
Submission Information

Author Name	Arpita Ray
Title	Genotoxic effects of fungicide(s) in the fish Pethia conchonius (Hamilton, 1822) from river Teesta of northern region of West Bengal
Paper/Submission ID	2225857
Submitted by	nbuplg@nbu.ac.in
Submission Date	2024-08-13 11:19:02
Total Pages, Total Words	107, 34579
Document type	Thesis

Result Information

Similarity **6 %**



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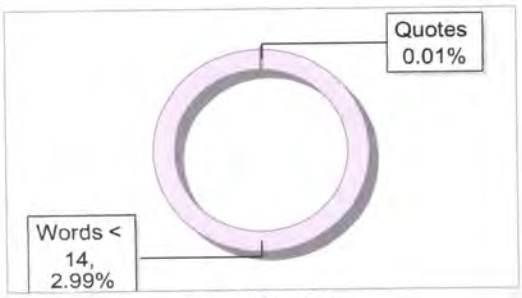

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Database Selection

Language	English
Student Papers	Yes
Journals & publishers	Yes
Internet or Web	Yes
Institution Repository	Yes

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Acknowledgment

I take this opportunity to express my deep sense of gratitude and indebtedness to those who helped me in carrying out this investigation.

My family have been a constant source of inspiration throμghout my doctoral study, without their support and encouragement it was quite impossible to finish such hard work.

I am immensely indebted and sincerely grateful to my honourable supervisor Prof. Min Bahadur, Genetics and Molecular Biology Laboratory, Department of Zoology, University of North Bengal. His invaluable sμggestions, guidance and supervision throμghout my work help me to solve problems and to take correct decisions during hard times of my research work.

I am thankful to Prof. Dhiraj Saha, Head, Department of Zoology, University of North Bengal for ensuring the necessary facilities in the Department, particularly the instrumentation facility. I express my thanks to my respected teachers Prof. Soumen Bhattacharya, Dr. Tilak Saha (Associate Professor), Dr. Sourav Mukherjee (Assistant Professor), Dr. Arpan Kumar Maiti (Assistant Professor), Dr. Ritwik Mondal, Dr. Subhra Prkash Hui for their valuable guidance during my work.

I would like to acknowledge Dr. Debi Sharma, Dr. Partha Pratim Chowdhury, Food Safety Referral Laboratory, ICAR-IIHR, Bangalore for their untiring help for LC-MS/MS analysis.

I would like to sincerely acknowledge Council of Scientific and Industrial Research-Human Resource Development Group for providing financial support as a fellowship (CSIR-HRDG Vide File No. 09/285(0095)/2019-EMR-I).

I am grateful to Dr. Bappaditya Ghosh, Dr. Mahua Rudra and Mr. Goutam Debnath for their guidance and unconditional cooperation as my elder sister and elder brother, respectively.

I am also thankful to Dr. Susmita Dutta, Mrs Swati Singh, Mrs Trisita Mazumdar, Dr. Saμgata Ghosh, Mr. Debojit Dutta for their untiring help and support throμghout my work.

Special thanks will go to my colleagues Mr. Debojit Dutta, Mr. Sourav Sarkar, Mr. Debabrata Modak, Mr. Rejuan Islam and Mr. Subhajit Das.

I would like to thank Mr. Suman Biswas, Ms. Esha Bhattacharya, Mr. Joydip Nag and Ms. Aritri Sarkar for their immense help.

I would like to thank Mr. Ratan Sarkar (Fisherman), Badal Sarkar (Fisherman), Mr. Debojit dutta, Ms. Esha Bhattacharya, Mr. Suman Biswas, Mr. Joydip Nag for cooperating me during sample collection.

I would like to thank Mr. Praveen Kumar Mishra for his help in chemical supply.

I am thankful to Dr Sutanuka Chattaraj, Dr. Uttara Dey Bhowmick, Dr. Subhashis Paul, Mr. Tanmoy Dutta, Mr. Sudipto Kumar Roy, Dr. Minu Bharti, Dr. Priyanka Rai, Mr. Abhishek Subba, Mr. Manas Pratim Modak, Ms. Prerna Bhujel, Ms. Nilu Limboo, Mr. Abhirup Saha, Mr. Sagar Sarkar, Mr. Amlan Jyoti Ghosh, Mr. Supriyo Ghosh, Mr. Arijit Deb, Ms. Sashwati Ghosh, Ms. Farha Yasmin, Mr Sona Sutradhar, Mr. Arun Roy for extending their helping hands.

Thanks, are also due to the non-teaching staff Mr. Sudam Das, Mr. Samiran Debnath, Mr, Amit Kumar, and Mr. Tapan Das of the Dept. of Zoology for their assistance in departmental facilities.

I am also thankful to all administrative staff for their help during my Ph.D. work.

In the end, I thank all those who helped me or were associated with my work directly or indirectly.

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Preface

Agriculture is the back bone of India's economy, contributing around 17-18% to the GDP and employing about 50% of the workforce. Pesticides, including fungicides, are crucial for protecting crops from pests and diseases, enhancing productivity, minimizing crop losses, and maintaining produce quality. However, fungicides can run off into nearby water bodies, posing significant risks to aquatic ecosystems. This runoff leads to changes in the physicochemical properties of water, affects aquatic organisms, and causes biodiversity loss. Fungicides bioaccumulate in the aquatic organisms, affect trophic level of the entire food chain including birds and mammals. These hazardous chemicals can damage aquatic plants essential for ecosystem.

The Teesta River, a major river in West Bengal, originates from the Himalayas and flows through Kalimpong, Darjeeling, Jalpaiguri, and Cooch Behar in North Bengal. It is reported to be contaminated with several fungicides due to agricultural activities along its banks. To address the lack of information on the detrimental effects of fungicides on the aquatic organisms of Teesta, this study focuses on the resident fish *Pethia conchonius*. The research evaluates the genotoxic effects of the fungicides azoxystrobin and difenoconazole on *Pethia conchonius*.

The investigations stated in this thesis were conducted in the Genetics & Molecular Biology Laboratory, Department of Zoology, University of North Bengal. The thesis is comprised of five chapters. **Chapter 1** has an **Introduction**, a **Review of literature**, and **Objectives**. **Chapter 2** contains the **Materials and Methods** section of the entire study. **Chapter 3** presents the **Results** of the sampling, analysis of fungicide residue, acute toxicity bioassay, assessment of DNA and nuclear damages, study of biochemical changes, and study of gene expression in various tissues, and the others. **Chapter 4** includes a detailed **Discussion** of the findings obtained in the present investigation, leading to a **conclusion**. The **Research articles** and **papers presented during different conferences,** an **Appendix** are included.in **Chapter 5.** In addition, the chapter also contains a **Bibliography** and **Index**.

Abbreviations

4-HNE: 4-Hydroxynonenal

AChE: Acetylcholinesterase

AOAC: Association of Official Analytical Collaboration

apaf: apoptotic protease activating factor-1

APHA: American Public Health Association

AZX: Azoxystrobin

Bax: bcl2 associated X protein

BChE: Butyrylcholinesterase

Bcl2: b-cell lymphoma/leukemia-2

BL: Blebbed

BLAST: Basic Local Alignment Search Tool

BSA: Bovine Serum Albumin

CAS: Chemical Abstracts Service

casp: Caspase

CAT: Catalase

CBZ: Carbendazim

CDNB: 1-Chloro-2,4-dinitrobenzene

CHE: Cholinesterase

CYP: Cytochrome p40

DMI: Demethylation inhibitor

DMSO: Dimethyl sulfoxide

DNA: Deoxyribonucleic acid

dNTP: Deoxynucleotide triphosphate

DPX: Distyrene Plasticizer Xylene

$DT_{50:}$ Dissipation time (Half-life)

DTNB: 5,5′-dithiobis-(2-nitrobenzoic acid)

DZ: Difenoconazole

E2: 17b-estradiol

EBDC: Ethylenebisdithiocarbamate

EC_{50}: half maximal effective concentration

EDTA: Ethylenediamine tetraacetic acid

ENA: Erythrocytic nuclear abnormalities

EPA: Environmental Protection Agency

EROD: 7-ethoxy-resorufin-O-deethylase

ETU: Ethylenethiourea

FAO: Food and Agriculture Organization

FAOSTAT: Food and Agriculture Organization Corporate Statistical Database

FICCI: Federation of Indian Chambers of Commerce & Industry

g: gram

G6PD: Glucose-6-phosphate dehydrogenase

GDP: Gross Domestic Product

GOI: Government of India

GPx: Glutathione peroxidase

GR: Glutathione Reductase

GSH: Glutathione

GSI: gonadosmotic index

GSSG: Glutathione disulfide

GST: Glutathione S-transferase

H_2O_2: Hydrogen peroxide

hsd: Hydroxysteroid dehydrogenases

IBM: International Business Machines Corporation

IGFBP: Insulin-like growth factor binding protein

ILO: International Labor Organization

IUCN: International Union for Conservation of Nature

IUPAC: International Union of Pure and Applied Chemistry

L: liter

LC_{50}: Median Lethal concentration

LCMS: Liquid Chromatography Mass Spectrometry

LDH: Lactate dehydrogenase

LOOH: Lipid Hydroperoxide

LPO: Lipid peroxide

MAPK: Mitogen-activated protein kinase

MDA: Malondialdehyde

Mdm2: Murine double minute 2

mg: milligram

MMP: Mitochondrial Membrane Potential

MN: Micronucleus

NA: Nuclear Abnormality

NAC: N-acetylcysteine

NADH: Nicotinamide adenine dinucleotide (NAD) + hydrogen (H)

NBT: Nitro blue Tetrazolium

NCBI: National Center for Biotechnology Information

ng: nanogram

NO: Notched

NRC: National Research Council

OECD: The Organization for Economic Co-operation and Development

OP: Organophosphate

OTM: Olive Tail Moment

p: Probability value

PBS: Phosphate Buffered Saline

*Pc*DM: *Pethia conchonius* specimens from site III (Domohoni)

*Pc*GB: *Pethia conchonius* specimens from site II (Gajoldoba)

PCR: Polymerase Chain Reaction

*Pc*SV: *Pethia conchonius* specimens from site I (Sevok)

PMS: Phenazine methosulfate

POD: Peroxidase

PUFAs: Polyunsaturated Fatty Acids

PYR: Pyraclostrobin

RNA: Ribonucleic acid

ROS: Reactive Oxygen Species

SCGE: Single Cell Gel Electrophoresis

SD: Standard Deviation

SE: Standard Error

SLC: Sub-lethal concentration

SOD: Superoxide Dismutase

SPSS: Statistical Package for the Social Sciences

TBARS: Thiobarbituric acid reactive substances

TBZ: Tebuconazole

TCA: Trichloroacetic acid

TNFR: Tumor necrosis factor receptors

USEPA: United States Environmental Protection Agency

USGS: United States Geological Survey

vtg: vitellogenin

WHO: World Health Organization

μg L^{-1}: micrograms per liter

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