

A STUDY ON THE STATUS OF ARSENIC IN SOME SELECTED ELEMENTS OF ENVIRONMENT



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**A Thesis
Submitted to the
West Bengal University of Animal and Fishery Sciences
in Partial fulfilment of the requirements for the Degree of
Master of Veterinary Science
in
ANIMAL PRODUCTS TECHNOLOGY & MARKETING**

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2003**

Dedicated to
My Parents



West Bengal University of Animal & Fishery Sciences

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Certificate

This is to certify that the work recorded in the thesis entitled "A Study on the Status of Arsenic in Some Selected Elements of Environment" submitted by Shyamal Kumar Das in partial fulfilment of the requirements for the degree of Master of Veterinary Science in "Animal Products Technology & Marketing" of the West Bengal University of Animal and Fishery Sciences, is the faithful and bonafied research work carried out under my personal supervision and guidance. The results of the investigation reported in the thesis have not so far been submitted for any other Degree or Diploma. The assistance and help received during the course of investigation have been duly acknowledged.

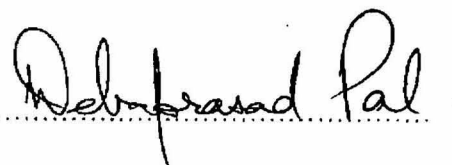
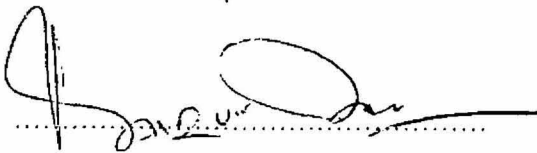
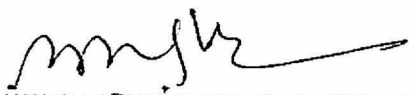
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We, the undersigned, having been satisfied with the performance of Shyamal Kumar Das in the viva-voce examination conducted today, the 24th Sept. 2003, recommended that the thesis be accepted for the award of Master Degree.

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Dated, Belgachia

the 25th Aug, 2003


(Shyamal Kumar Das)

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List of Abbreviations Used

AAS	Atomic absorption spectrometre
As.	Arsenic
&	And
°C	Degree centigrade
d.f.	Degree of freedom
DMA	Dimethylarsinic acid
et al.	And others
etc.	Et cetera
g	Gram
G.P.	Gram Panchayet
kg	kilogram
l	Litre
MFPO	Meat Food Products Order
mg	Milligram
min	Minute
µg	Microgram
µg	Micrometer
MMA	Monomethylarsonic acid
nm	Nanometre
%	Percentage
ppb	Parts per billion
ppm	Parts per million
rpm	Rotation per minute
SDDC	Silver diethyldithiocarbamate
SE	Standard error
UV	Ultraviolet
v/v	Volume by volume
Vs.	Versus
WHO	World Health Organization

There is also substantial evidence in animals that arsenic is an essential trace element in a very minute quantity (35-50 ppb) in rats, goats, mini-pigs, and chicks on the basis of the observation of growth retardation in animals when fed with purified diets (Anke *et al.*, 1991; Nielsen, 1996), however the requirements are generally met by feeds and water normally consumed and there is no need of supplementation from extraneous source. But due to overdose or high concentration of arsenic in feed and water or chronic ingestion of arsenic contaminated feed and drinking water may produce toxicity to the animals. Effects of chronic arsenic toxicity in animals should be overemphasized because large chemical exposure is needed to acute toxic signs which would be recognized immediately and the source of exposure would be found and eliminated whereas chronic arsenic toxicity occurs over large areas, affect a large number of animals due to long term low level exposure.

Till few years back the main source of water for domestic animals and poultries was surface water (Ponds, canals, rivers, lakes etc.) which was safe from arsenic contamination but now-a-days animals or birds are forced to take ground water (from shallow tube well with 60 - 100 feet depth) which may not be safe due to its elevated arsenic contents.

Arsenic contaminated ground water is not only used for drinking purpose but also for agricultural irrigation. It is expected tons of arsenic is coming with underground water in the arsenic-affected areas of West Bengal and Bangladesh and falling on irrigated land. Mandal (1998) reported that in a 201 km² area of the Deganga block in arsenic affected district of North-24 parganas, West Bengal, 6.4 tones of arsenic is falling on the soil as a result of using water from 3,200 contaminated shallow tube wells for agricultural irrigation. Again, surface water is also being polluted by arsenic contaminated run off water from irrigated agricultural field. So it is expected that plants, terrestrial and aquatic biota are also the likely victims of such catastrophes arising from arsenic pollution. Thus arsenic contaminated agricultural products, animal and fish products may also contribute towards the chronic arsenicosis in human being through food chain.

CHAPTER
I

INTRODUCTION

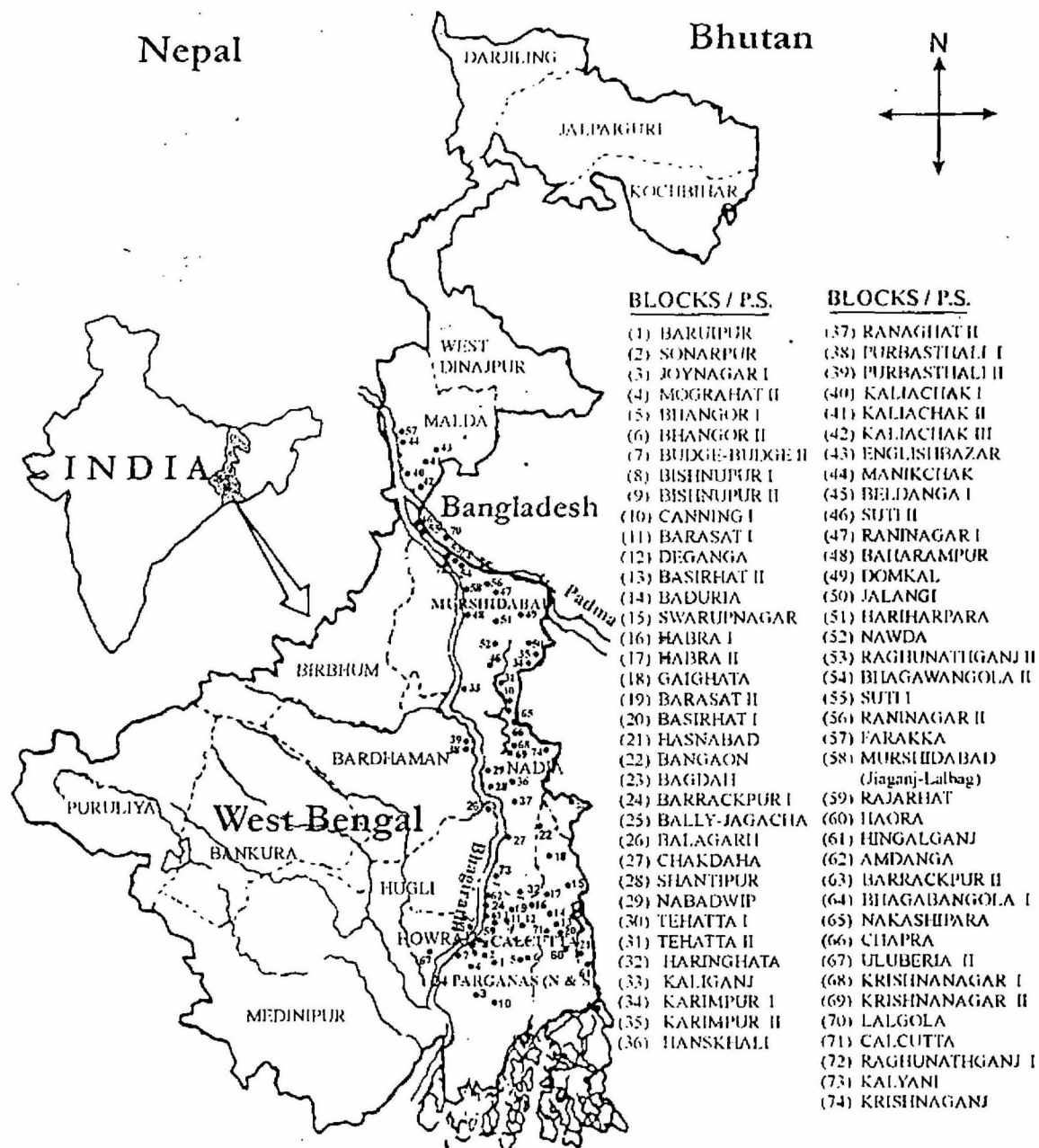
Introduction

Arsenic is known for a long time and the word is derived from the Greek word 'arsenicon' means 'fearless'. As early as pre-Christian era, the word becomes synonymous with poison.

Arsenic is a metalloid widely distributed in the earth's crust but the pure metallic arsenic is not common in the environment. Many arsenic containing compounds both inorganic and organic are naturally occurring in rock, soil, water, air. It can be further released in the environment through natural activities, such as volcanic action, erosion of rock or through anthropogenic action like burning of fossil fuel, melting of metal ore, cement manufacturing and mining run off, use of pesticide and of course injudicious pumping of ground water from arsenic rich bedrock.

In the world there are approximately 21 countries where incidents of arsenic contamination of ground water are known. However, world's two biggest cases of ground water contamination and worst suffering of people by arsenic have been surfaced in Bangladesh (Dhar *et al.*, 1997) and in West Bengal, India (Mandal *et al.*, 1998). In a report while narrating the magnitude of arsenic calamity in Bangladesh, Pearce (1998) mentioned that tens of million of people are at risk and 43,000 villagers out of 68,000 are presently or could be at risk in future. In the same report the World Health Organization (WHO) predicted that within a few years, 1 in 10 adults death occurs in southern Bangladesh could be from cancers triggered by arsenic.

Recent studies (upto 2001) revealed that there are 2600 villages from 74 blocks in 9 districts out of a total 18 districts of West Bengal and 2000 villages from 178 blocks in 47 districts out of a 64 districts of Bangladesh where ground water is containing arsenic above the maximum permissible limit of 50 $\mu\text{g/l}$ as determined by WHO (1984). At least 6 million people of West Bengal and 25 million people of Bangladesh are drinking arsenic contaminated tube well water which exceeds this limit and more than 100 million people are at risk of arsenic contamination in West Bengal and Bangladesh (Chowdhury *et al.*, 2001).



• Blocks where arsenic levels in groundwater are above 50 µg/L

Fig. 1. Map showing the arsenic-affected areas and blocks/police stations of West Bengal.

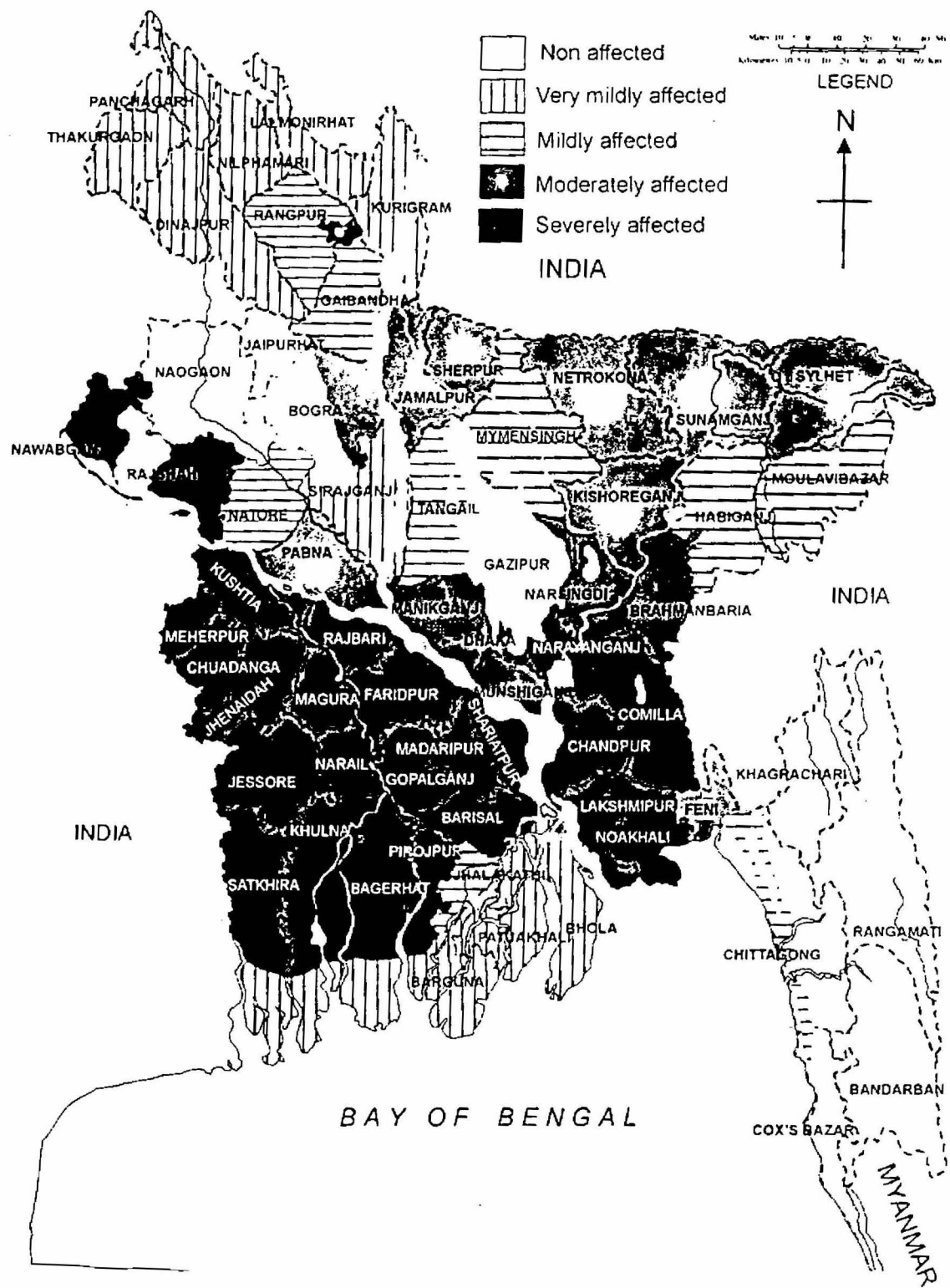


Fig. 2 . Map showing the status of arsenic levels in groundwater in all 64 districts of Bangladesh.

With this in mind a maiden attempt has been planned to generate some of the important information about the quantum of arsenic deposition in different tissues, products and excreta of terrestrial and aquatic life. The effect of rearing system (birds), species (fish), sex and age on deposition of arsenic were also planned for study.

Besides residual study, the basic concept is again been extended with incorporation of some pathomorphological study of the different organs of animals, showing manifestation of symptoms of arsenicosis.

Available published literature did not reveal much information in the above lines. Hence, the present studies were planned with objectives to generate information on arsenic profile in some selected terrestrial and aquatic elements as outlined below :

- 1) To study the level of arsenic in different terrestrial and aquatic elements.
- 2) To study the distribution of arsenic in different organs, products and excreta of the animals.
- 3) To study the human health hazards through consumption of animal products and fish.
- 4) To study the effect of rearing system, species, sex and age of the selected biota on deposition of arsenic.
- 5) To study the pathomorphological changes in animals.

CHAPTER II

Review of Literature

2.1. Properties of arsenic :

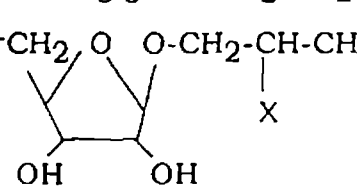
Arsenic is a ubiquitous element with metalloid properties. Elemental arsenic (As) is a member of Group 15 (old Group V) of the periodic table, with nitrogen, phosphorus, antimony and bismuth. It has an atomic number of 33 and an atomic mass of 75.91. It can exist in four valency states, -3, 0, +3 and +5. In strongly reducing environments, elemental arsenic and arsenic (-3) can exist. Under moderately reducing conditions, arsenite (+3) may be the dominant form, but arsenate is generally the stable oxidation state in oxygenated environments.

Most environmental transformation of arsenic appear to occur in the soil, in sediments, in plants and animals and in zones of biological activity of oceans.

Andrae (1983) reported that three major modes of biotransformation of arsenic species have been found to occur in the environment : redox transformation between arsenite and arsenate, the reduction and methylation of arsenic and the biosynthesis of organoarsenic compounds. There is biogeochemical cycling of compounds formed by these processes.

Elemental arsenic is not common in the environment. Rather arsenic is usually found combined with one or more other elements. Arsenic compound without carbon referred to as inorganic arsenic compound, where as arsenic combined with carbon and hydrogen in referred to as organic arsenic compounds.

Naturally occurring inorganic and organic arsenic compounds.

Name	Abbreviation	Structure
Arsenite	As(III)	$\begin{array}{c} \text{O}^- \\ \\ \text{O}^- - \text{As} - \text{O}^- \end{array}$
Arsenate	As(V)	$\begin{array}{c} \text{O} \\ \\ \text{O}^- - \text{As} - \text{O}^- \\ \\ \text{O}^- \end{array}$
Monomethylarsonic acid	MMA	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{As} - \text{OH} \\ \\ \text{OH} \end{array}$
Dimethylarsinic acid	DMA	$\begin{array}{c} \text{O} \\ \\ \text{CH}_3 - \text{As} - \text{OH} \\ \\ \text{CH}_3 \end{array}$
Trimethylarsine oxide	TMAO	$(\text{CH}_3)_3 \text{As} = \text{O}$
Tetramethylarsonium ion	Me_4As^+	$(\text{CH}_3)_4 \text{As}^+$
Arsenobetaine	AsB	$(\text{CH}_3)_3 \text{As}^+ \text{CH}_2 \text{COO}^-$
Arsenocholine	AsC	$(\text{CH}_3)_3 \text{As}^+ \text{CH}_2 \text{CH}_2\text{OH}$
Arsenic containing ribosides	Arseno sugar X-XV ^a Arsenolipid ^b	
Arsenosugar ^a		
	R	X
X	$(\text{CH}_3)_2 \text{As} (\text{O})-$	- OH
		Y
		- OH

XI	$(\text{CH}_3)_2 \text{As} (\text{O})-$	- OH	$\text{OPO}_3\text{HCH}_2\text{CH}(\text{OH})\text{CH}_2\text{OH}$
XII	$(\text{CH}_3)_2 \text{As} (\text{O})-$	- OH	-SO ₃ H
XIII	$(\text{CH}_3)_2 \text{As} (\text{O})-$	- OH	-OSO ₃ H
XIV	$(\text{CH}_3)_2 \text{As} (\text{O})-$	- NH ₂	- SO ₃ H
XV	$(\text{CH}_3)_3 \text{As}^+$	- OH	-OSO ₃ H

Arsenolipid^b

R	X	Y
$(\text{CH}_3)_2 \text{As} (\text{O})-$	-OH	$\text{OPO}_3\text{HCH}_2\text{CH}(\text{OPalm})\text{CH}_2\text{OPalm}$
Palm = Palmitolate group		

Compounds of arsenic (V) - inorganic and organic - are less toxic than those of arsenic (III); organic compounds are less toxic than inorganic ones, and insoluble compounds are less toxic than soluble ones. Arsenic (III) is the active form of arsenic, and it combines with sulfhydryl groups of many enzymes. As a result the formation of acetyl lipoate or acetyl-coA is inhibited.

2.2. Analytical procedures :

The most commonly used technique for the determination of arsenic involve its transformation into arsine. Measurements of arsine can be carried out using spectrophotometry.

Spectrophotometry of the silver diethyldithiocarbamate complex of arsine has been used historically for the determination of arsenic. This method is easy to use, is inexpensive in terms of equipment and operator costs.

Besides, there are several methods for the determination of minute amount of arsenic. These methods are namely :

1) Colorimetric method :

a) Ammonium molybdenum blue method.

2) Atomic spectrometry :

- a) Flame atomic absorption spectrometry (FAAS).
 - b) Electrothermal or Graphite Furnace - AAS. (EAAS or GFAAS).
 - c) Hydride generation AAS (HGAAS).
- 3) ICP methodologies :
- a) Inductively coupled plasma mass spectrometry (ICP-MS).
 - b) Inductively coupled plasma atomic emission spectrometry (ICP-AES)
- 4) Voltametry :
- a) Differential pulse cathodic stripping voltametry (DDCSV) coupled to a hanging mercury drop electrode (HMDE).
- 5) Radiochemical method :
- a) Neutron activation analysis (NAA) method.
- 6) X-ray spectroscopy :
- a) Particle-induced X-ray emission spectrometry (PISES).
 - b) X-ray fluorescence (XRF) spectroscopy.
 - c) X-ray absorption fine structure (XAFS) spectroscopy.
- 7) Hyphenated techniques :
- a) Anion exchange High pressure liquid chromatography and Inductively coupled plasma mass spectrometry (Anion exchange (HPLC - ICP - MS) method.
 - b) High pressure liquid chromatography and inductively coupled plasma atomic emission spectrometry (HPLC - ICP - AES) method.
 - c) Micellar liquid chromatography (MLC) and ICP - MS (MLC - ICP - MS) method.

2.2.1. Spectrophotometric method :

Using the silver diethyldithiocarbamate method, **Tarrant and Allard (1972)** studied the urinary excretion of arsenic.

George et al. (1973) carried out spectrophotometric measurement of arsenic in poultry and swine tissue using silver diethyldithiocarbamate as the complexing agent.

Pradit and Saowani (1991) analyzed the quantity of arsenic in the water using silver diethyldithiocarbamate in an arsine generator and an absorption tube. The light absorbance of the silver complex compound was measured by an ultraviolet-visible spectrophotometer which has a double beam and a one centimetre cell at 535 nanometer.

Doganoc and Florjanc (1997) estimated arsenic content of meat and meat products, eggs, milk and milk products, fresh water fishes and marine fishes, using spectrophotometry with silver diethyldithiocarbamate in pyridine.

Bilgili et al. (1999) measured arsenic residue in grey mullet (*chalcarburnus tarichii, pallas* 1811) by silver diethyldithiocarbamate in spectrophotometer.

2.2.2. Other Methods :

Using microwave dissolution in a closed Teflon bomb followed by hydride generation atomic absorption spectrometry **Navarro et al. (1992)** analysed arsenic in 32 locally consumed fish species from the coast of the province of Granada, Spain. The recovery percentage ranged from 96.33 to 100%.

Croteau et al. (1994) described an analytical method of determination of 3-nitro-4-hydroxy phenylarsonic acid in tissues. It involves extraction of 3-nitro-4-hydroxy phenylarsonic acid from swine tissues by microwave assisted process followed by high performance liquid chromatography. The detection limit is estimated to be 0.25 µg/g for 3-nitro, equivalent to about 0.2 µg/g of arsenic.

2.3. Arsenic in water :

Concentrations of arsenic in open ocean seawater are typically 1-2 µg/litre. Levels of arsenic in estuarine water varies from 0.7 to 4.9

µg/litre. Surveys of arsenic concentrations in rivers and lakes (Surface freshwater) indicate that most values are below 10 µg/litre, although individual samples may range up to 1 mg/litre.

Arsenic levels in ground water average about 1-2 µg/litre, except in areas with volcanic rock and arsenic rich bed rock (sulfide mineral deposits) where arsenic levels can range up to 3400 µg/litre (WHO, 2001).

Matisoff et al. (1982) found no evidence for an anthropogenic source contributing to elevated groundwater levels of arsenic (<1 to 100 µg/litre) in north eastern Ohio (USA). The authors stated that the arsenic appeared to be of natural origin.

Bokori and Gyori (1989) studied the samples of top water (12) and drinking water from wells, dug, drilled and artesian (15) in large scale pig, cattle and poultry farms. Arsenic was 0.1 to 0.18 mg/litre in the drinking water of the Farms.

Varsanyi (1989) found arsenic concentrations in deep ground water in Hungary to range from 1 to 174 µg/litre with an average value of 68 µg/litre.

Del Razo et al. (1990) monitored ground water in the Lagunera region of northern Mexico. Total arsenic concentrations ranged from 8 to 624 µg/litre with over 50% of samples >50 µg/litre. The predominant arsenic species in 93% of samples was arsenate, although in 36% of samples, 20-50% arsenite was found.

Pradit and Saowani (1991) analyzed the amount of arsenic in the water in Songkhla lake. Twelve samples were analyzed. The finding revealed that there was 0.003-0.015 ppm of arsenic in the water Songkhla lake.

Caceres et al (1992) reported the levels of arsenic in surface water (river and creeks) ranged from less than 100 to over 80 µg/litre at Aracamenan settlement near Caluma in Northern Chile. The source

of the arsenic have been reported as volcanic sediments, minerals and soil.

Wu-Zhili, et al. (1993) reported that the agricultural environment in Shniquan village has been polluted by the tailing water containing high concentration of arsenic used for irrigation from a copper smeltery. They reported the drought cattle in this region are harmed due to the accumulation of this element.

Chen et al. (1994) reported that arsenic levels in the ground water of South-West-Taiwan contained mean dissolved arsenic levels of 671 µg/litre.

Chartterjee, et al. (1995) analysed ground water from West Bengal (India) with a maximum value of 3700 µg/litre. Mean arsenite levels in the groundwater were around 50% of the total arsenic.

Kurttio et al. (1998) observed high arsenic levels in drilled wells in South-West Finland. The arsenic was originated from arsenic rich bedrock and the concentration in water was ranging from 17-980 µg/litre.

Rosas et al (1999) found that the total inorganic arsenic concentration in well water in Comarca Lagunera, Mexico ranged from 7 to 740 µg/litre and 90% of the arsenic was found as As (V).

Chowdhury et al. (2001) reported that 25.5% and 37% of groundwater samples collected from West Bengal (India) and Bangladesh contained total arsenic levels >50 µg/litre.

2.4. Arsenic in sediment :

Crecelius (1974) studied that the natural level of arsenic in sediments is usually below 10 mg/kg dry weight. Bottom sediments can become substantially contaminated by arsenic from man-made sources. Levels upto 10,000 mg/kg dry weight were found in bottom sediments near a copper smelter in Washington, USA.

Farmer and Lovell (1986) monitored arsenic concentrations in surface sediments of Loch Lomond (Scotland, UK); no recent significant sources of environmental arsenic contamination were identified. They found natural enrichment of sediment to levels of up to 675 mg As/kg compared with typical background concentrations of 15-20 mg/kg.

Welch et al. (1988) reported that sediments in aquatic systems often have higher arsenic concentrations than those of the water.

2.5. Arsenic in Soil :

Arsenic is found in the igneous and sedimentary rocks at an average level of 2 mg/kg. Arsenic is present in soils in higher concentrations than those in rock. Most natural soils contain low levels of arsenic but irrigation run off pesticides application, mine on industrial water may increase concentration in agricultural soil. Background concentrations in soil range from 1 to 40 mg/kg, with a mean value of 5 mg/kg (**Beyer and Cromartie, 1987**). Organic and inorganic arsenicals in soil behave similarly. They react with iron in conjunction with clay and other particles or with various cations in soil to form insoluble complexes. Sandy or low clay soils have less affinity for arsenic. Larger concentrations are found in alluvial soils and in organic soils.

Takamatsu et al. (1982) recorded mean total arsenic concentration of agricultural soils treated with arsenical pesticides was 50-60 mg/kg.

Chutke et al. (1995) analysed dust samples collected from Nagpur city, India during 1992. Mean arsenic levels for residential / commercial areas, industrial areas and highways were respectively 10.2, 18 and 17 mg/kg (dry weight).

Kavanagh et al. (1997) reported total arsenic concentrations ranging from 174 to 477 mg/kg for agricultural soil in the Tamar Valley, South West England. The proportion of water extractable arsenic in agricultural top soils ranged from 0.05 to 0.3%.

Rosas et al. (1999) determined the arsenic level in fifty samples soil in Comarca Lagunera, Mexico. The agricultural soil texture of the sampled area was sandy clay loam type with total arsenic levels up to 30 µg/g.

2.6. Arsenic in Plant and Feed :

The arsenic content of plants grown on soils that had never been exposed to arsenic pollution varied from 0.02 to about 5 mg/kg (dry weight). Plants grown in arsenic contaminated soils may, however, contain considerably higher levels, especially in the roots.

Woolson (1973) dosed with arsenate in soil at the concentration (0-500 µg/g) which inhibited growth of vegetable crops (green bean, lima bean, spinach, cabbage, tomato and radish), high levels of accumulation when found in the edible parts of radish (76 µg/g), spinach (10 µg/gm) and green bean (4.2 µg/g). Arsenic accumulation in Lima bean, cabbage and tomato ranged from 0.7 - 1.5 µg/g.

Temple et al. (1977) found mean arsenic levels of 5.8 mg/kg in grass samples and 7.4 mg/kg in tree and shrub foliage from within 700 m of a secondary lead smelter whereas samples collected at a control site contained < 1 mg/kg.

Arsenic uptake into plants occur either via root or by foliar uptake. The following generalizations have been made by **Woolson (1983)** about the arsenic content of plants resulting from root uptake.

a) Plants grown on sands and sandy loams have higher residues at equivalent soil levels than those grown on heavier texture soil (clay slits).

- b) Fruits has lower levels than leaves, stems on roots.
- c) Roots contain the highest levels.
- d) Residues are low unless plant growth is severely affected

Merry et al. (1986) reported that pasture plant growing at sites used as orchards contained less than 2.5 mg As/kg (dry wt.) where concentration of arsenic in soil was 80 mg/kg.

Grainger (1988) observed that the mean concentration of arsenic in 28 samples of lettuce collected from mining area of corn wall, UK was 0.85 µg/g dry weight. He also found that the mean concentration of arsenic ranged from 0.21 µg/g for carrots to 0.04 µg/g for peas and beans. It has been estimated that cattle in this area may have an intake of arsenic of upto 50 mg daily.

Schwarz, et al. (1991) studied that no serious problems could be detected with reference to contents of arsenic in roughage, grain and crops from two areas in the new federal republics of Germany. Only a few feed samples reached or exceeded the permissible upper limits for arsenic.

Onken and Hossner (1995) grew rice in two soil types treated with upto 45 mg As (III) or As (V)/kg (as arsenite or arsenate) for 60 days. The arsenic concentration of rice plants correlated with the mean soil solution arsenate concentration in the clay soil and to the mean soil solution arsenite for the silt loam. The rate of arsenic uptake by plants increased as the rate of plant growth increased.

Helgesen and Larsen (1998) demonstrated that bioavailability of arsenic pentaoxide to carrots in soil from a wood preservative treatment plant was $0.47 \pm 0.06\%$ of total soil arsenic burden. This study showed that arsenite, arsenate, MMA, whereas only arsenite and arsenate were present in soil.

Rosas et al. (1999) estimated samples of lucerne (*Medicago sativa*). The most important crop. The total arsenic ranged from 0.24 to 3.16 µg/g.

2.7. Tissue distribution of arsenic in animal :

Absorbed arsenic not excreted is slowly released from the liver and become distributed to other tissues. Various tissues and fluids of animals and poultry differ in their indication of arsenic status.

Lindgren et al. (1982) showed that arsenic can cross the blood-brain barrier. However, the levels are uniformly low both time and relative to tissues, which indicates that arsenic does not readily cross the blood-brain barrier or accumulate in brain tissue. He also studied that in general, the concentrations of arsenic in organs tended to be higher the notable exception of the skeleton at all time points. This later finding was ascribed to arsenate being a structural analogue of phosphate and substitution for it in the apatite crystal of bone.

Danielson et al. (1984) showed that the arsenic is accumulated in the testis of rodents.

VanderKop and Mac Neil (1989) conducted a experiment where broilers fed a diet containing 100 or 500 mg/kg arsanilic acid accumulated up to 2.3 and 8 mg As/kg in liver tissue at the two exposure concentrations respectively. Lower levels were accumulated in muscle tissue, with arsenic concentrations of upto 0.15 and 0.67 mg/kg.

Jorhem et al. (1991) analysed several hundred samples of meat, liver and kidney from Swedish pigs and cattle. The mean arsenic levels in pig meat, liver and kidney were 0.024, 0.023 and 0.019 respectively and those in the corresponding bovine tissues were lower, none exceeding 0.015 mg/kg.

Proudfoot et al. (1991) found a higher concentration of arsenic in liver and muscle of broilers that were fed arsanilic acid (99 mg/kg diet) compared with controls. Mean arsenic residues of up to 1.5 mg/kg and 0.4 mg/kg were measured for two tissues respectively. He

Materials and Methods

The present study has been undertaken with the idea to know the status of arsenic in some selected elements of environment. The level of arsenic was measured in ground and surface water, pond sediment, soil, feeds and forages, different tissues, products and excreta of ^{terrestrial} animals (Bird and Bengal goat) and aquatic animals (fishes) during October, 2002 to July, 2003. In birds the parameters on which work has been undertaken are mainly rearing system, sex and age. In Bengal goat the parameters were sex and age. In fish the parameters were selected on the basis of species which takes feeds from various layers of aquatic environment and their age. Some pathomorphological work has also been conducted depending on the manifestation of symptoms of animals. On the basis of aforesaid parameters the following methods and techniques have been adopted in the present study.

- 3.1. Selection of site of experiment and sampling technique.
- 3.2. Estimation of total arsenic levels
- 3.3. Pathomorphological examination of selected samples
- 3.4. Statistical methods used.

3.1. Selection of site of experiment and sampling technique

3.1.1. Selection of site of experiment:

Considering the need for availability of data and limitations of post graduate research project a semi-microlevel comparative study of one arsenic affected block, Deganga from North 24 Parganas and one unaffected block, Debra from Paschim Midnapore in West Bengal were purposively selected for the present study. It has been reported that out of 18 districts in West bengal 9 districts are arsenic affected (Chowdhury *et al.*, 2001) and rest are unaffected and Midnapore is under one of the unaffected districts which has easy access of the researcher. So Debra block in Midnapore was considered as an unaffected block. It has been found that 40% hand tube wells and

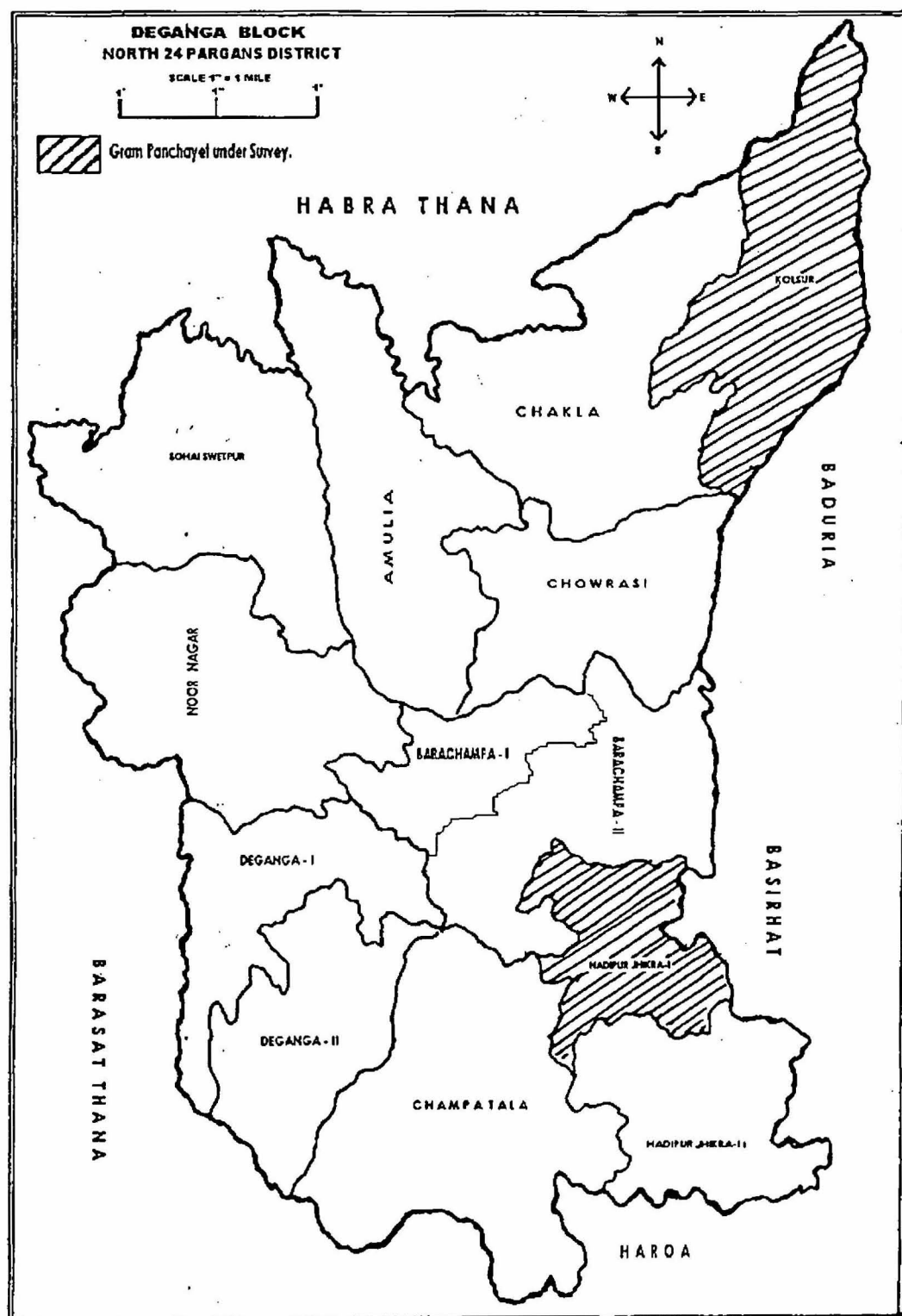


Fig. 3. Map showing area under survey in Deganga block, West Bengal.

also found a significant differences between muscles. The residue level of arsenic in breast muscle was 60% or more lower than in thigh muscle.

Salisbury *et al.* (1991) determined arsenic residue in liver and kidney tissues for cattle, swine, poultry, horse, calves and sheep in a national survey conducted between 1982 and 1989 in Canada. Arsenic was found in most avian and porcine samples and their respective means of 0.36 and 0.26 µg/g in liver were 7 to 12 times higher than mean concentration found in other species.

Arunsakul *et al.* (1992) studied arsenic residues in blood samples, liver, kidney, muscles and skin of swine. The values were 0.138, 0.332, 0.339, 0.120 and 0.138 ppm respectively. In livers and muscles of broilers were 0.520, 0.052 ppm and in blood samples livers, kidneys and muscles of cattle were 0.063, 0.059, 0.053 and 0.071 ppm respectively. The arsenic residues were lower than the standards recommended by Ministry of Public Health.

Hoffman *et al.* (1992) fed mallard on a diet containing 200 mg As (V)/kg (as sodium arsenate) for 4 weeks. Arsenic accumulated in the liver at a concentration of 2.3 mg As/kg (wet weight). Birds maintained on a restricted protein and exposed to the same arsenic contaminated diet accumulated 5.1 mg As/kg.

Kluge, B.S. (1993) studied samples of tissues from cattle up to 2 years and fattening pigs, collected every months at slaughter houses throughout Norway for the period 1988-92. The limit for arsenic was not exceeded (2.0 ppm codex). Median values in pigs and cattle were 0.01 ppm. Maximum values were 0.33 ppm and 0.44 ppm in pigs and cattle respectively.

Stanley *et al.* (1994) maintained mallards on diets containing 25, 100 or 400 mg As (V)/kg (as sodium arsenate) for 16-18 weeks. Arsenic was accumulated in a dose dependent manner; mean concentration in adult livers were 0.49-6.6 mg As/kg (dry weight), in

duckling livers from 0.66-33 mg/kg and in whole eggs from 0.46-3.6 mg/kg.

Ramos et al (1995) showed that in female rats arsenic concentration in the ovaries were as high as in the liver.

Zmudzki and Szokoda (1995) assessed the concentration of trace elements in muscle sample originating from 415 hens from small holdings and 450 from intensive rearing units throughout Poland. The mean level of arsenic in muscle was 0.01 mg/kg.

Doganock and Florjanc (1997) estimated arsenic content of meat and meat products, eggs, milk and milk products, fresh water fishes and marine fishes which were collected from Slovenia between 1988 to 1995. In the majority of the sample the arsenic content was < 0.05 mg/kg. Risk assessment showed that only 1% sample did not meet the regulation for food safety.

Prikhod' (1998) observed average concentration of As in the organs and tissues of chickens, fed on a diet balanced in crude protein and containing arsenic 1.02 mg/100g hardly exceed 1 µg/g. However, higher values were found in bones, 1.7 µg/kg, but in liver, heart muscle and skin values were 0.101 to .0150 µg/kg.

Spiric and Saicic (1998) analysed 849 pig, 584 cattle and 350 lamb samples for arsenic. In most samples toxic element was present at levels less than 50% of RL (Residue level). It is concluded that residue in tissues of food producing animals do not have a great potential impact on public health in Yugoslavia.

From monitoring studies in the USA by **Yost et al (1998)** it has been found that meats have higher concentration of arsenic than dairy products. It has been also estimated that the percentage of inorganic arsenic is about 75% in meats, 65% in poultry and 75% in dairy products.

Biswas et al. (2000) assessed the residual concentration of arsenic in Bengal goat after inducing chronic inorganic arsenic toxicity (at 25 mg/kg body weight) for 3 weeks. The largest residual

concentration of arsenic was in the liver ($75.70 \pm 2.21 \mu\text{g/g}$) followed by the intestine, kidneys, thyroid glands, abomasum, spleen, skin, hair, bone marrow, heart, skeletal muscles and lowest in brain tissue ($5.18 \pm 0.05 \mu\text{g/g}$). Tissues from the organs of the control animals contained arsenic less than $1 \mu\text{g/g}$.

2.7.1. Arsenic in blood :

Absorbed arsenic is transported in the blood, mainly bound to sulfhydryl (SH) groups in proteins and low molecular weight compounds such as glutathione and cysteine, to organs of the body.

According to **WHO (1981)** it has long been recognized that rats accumulate arsenic in the blood but in other animal arsenic does not accumulate in blood. The major part of both inorganic and organic arsenic in blood is cleared fairly rapidly. So blood arsenic reflects exposure for only a short period following absorption and is very time dependent. Only when exposure is continuous arsenic in blood level reach a steady state and there is a possibility of finding a relationship between blood arsenic and exposure. Only in cases of continued arsenic exposure is the blood arsenic level likely to be a useful indicator of the presence of arsenic in the body. The whole blood arsenic levels being 2-7 times higher than the plasma levels and the red cells contain about 3 times more arsenic than the plasma.

Heydorn (1970) studied on healthy individuals with no known exposure to arsenic indicate similar concentrations (about $2.5 \mu\text{g/l}$) in plasma and whole blood. Whereas, people from the area of Taiwan with arsenic rich water had $15.4 \mu\text{g/l}$ in plasma $32.7 \mu\text{g/l}$ in cell and $21.6 \mu\text{g/l}$ in whole blood. Patients with black foot disease and their families had about $38.1 \mu\text{g/l}$ in plasma, $93 \mu\text{g/l}$ in cell and $60 \mu\text{g/l}$ in whole blood.

Yamauchi and Yamamura (1985) characterized the forms of arsenic present and their distribution over time in whole blood, plasma and erythrocytes in hamster given a single oral dose at 4.5 mg/kg As₂O₃ [As (III)]. Arsenic levels in whole blood had dropped to control levels by 72 h after dosing indicating rapid clearance from the blood. In whole blood inorganic arsenic, MMA and DMA concentrations peaked 1, 12 and 24 h after dosing respectively, the levels of MMA and DMA achieved relative were 1/3 and 1/10 as high as those of inorganic arsenic. Inorganic arsenic and MMA were found mainly in erythrocytes and DMA occurred chiefly in plasma.

DeKimpe et al. (1996) studied that binding of arsenic to plasma protein is not strong. The kinetics and concentration of arsenite in erythrocytes were quite similar to that seen in plasma, but arsenate concentrations in erythrocyte were only about 1/10 as high.

2.7.2. Arsenic in Feather and Hair :

Arsenic is easily taken up by the cells of the root of hair or feather. Accumulation of arsenic rises with increasing arsenic intake, so level of ^{arsenic} in hair or feather provides a useful index of arsenic exposure.

Buck et al. (1976) made an estimation of arsenic content in hair samples and the values went up to 10-30 ppm and 5 ppm in acute and chronic arsenic poisoning respectively.

Riviere et al. (1981) assessed arsenic content in hair samples of cattle affected with arsenic poisoning and found the level was more than 3.40 ppm.

Zepeda and Martínez (1981) reported that arsenic was accumulated in feathers of fowl which ranged from 0.25-15 ppm.

Robb et al. (2002) showed that sheep of North Ronaldsay, eating high level of arsenic through seaweed, incorporated high arsenic concentration in wool (mean $5.2 \pm 2.3 \mu\text{g/g}$)

Vaheter and Marafante (1983) suggested that the greater retention of arsenite in keratin rich tissue such as hair and nails is a consequences of its reactivity and binding with tissue constituents, most notably sulfhydryl groups.

2.7.3. Arsenic in Urine and Faeces

High urinary arsenic concentration can indicate exposure to high concentrations of toxic inorganic arsenic or recent consumption of certain foods, especially those of marine origin. In general, organoarsenicals are extensively metabolized than inorganic arsenic and more rapidly eliminated.

Buck et al. (1976) reported that only about 1/5th of absorbed arsenic is promptly excreted through urine and faeces. The remaining 4/5th is stored widely in body.

Underwood (1977) remarked that arsenic absorption, retention, and the routes of excretion are influenced by the level and the chemical form in which it is ingested. He also reported that organically bound As which ordinarily occurs in food is well absorbed and rapidly eliminated mainly in the urine, whereas, inorganic form of As is also well absorbed but more of it is retained in the tissues.

Vaheter and Norin (1980) compared that the urinary and faecal elimination in mice that have given the same dose of arsenic by oral and parenteral routs Results revealed that only 4-8% of the dose is eliminated in faeces irrespective of route of administration. This suggests that, biliary elimination of arsenic in mice is quite low and that most arsenic appearing in the faeces after oral dosing was unabsorbed from the gastrointestinal tract.

Buchet et al. (1981a) studied generally 40-60% of the daily intake of inorganic arsenic is excreted each day in urine.

Buchet et al. (1981b) also studied that the methylated metabolites MMA and DMA are excreted in the urine faster than the inorganic arsenic. In humans, 78% of MMA and 75% DMA were excreted in the urine within 4 days of ingestion of the dose.

Vaheter (1994) reported that the concentration of that arsenic in urine is generally accepted as a good indicator of the absorbed amount of arsenicals, because excretion via urine is the primary route from most animals.

2.8. Tissue distribution of arsenic in fish :

Arsenic residue in fish appear to show substantial variation. Freshwater fish have not been seen to accumulate arsenic to the same degree as marine fish. Marine water fish tends to accumulate much higher levels of arsenic than freshwater fish.

Lunde (1972) studied the distribution of organic arsenic in fish (Rainbow trout), fed a marine diet containing about 15 mg As/kg in the form of organoarsenic compound to which inorganic arsenic in the fish was negligible. Auto radiography revealed that the ^{74}As was especially concentrated in the eyes, throat, gills and pylorus organs. The liver and kidney also contained much radioactivity.

Sorensen (1979) found that green sunfish (*Lepomis cyanellus*) exposed to 60 mg As (V)/litre for 6 days accumulated mean arsenic residues of 158.7, 47.5, 18.9 and 14.2 mg/kg in the gallbladder (plus bile), liver, spleen and kidney respectively.

Oladimeji et al. (1984) fed rainbow trout (*O. Mykiss*) a diet containing 10, 20 or 30 mg As (III)/kg (as sodium arsenite) for upto 8 weeks. Arsenic accumulation was dose related with residues ranging from 1.28 to 1.52 mg/kg (dry weight) for muscle, 1.55 to 5.21 mg/kg

for liver, 0.84 to 1.88 mg/kg for gills and 1.21 to 1.98 mg/kg for skin tissue.

Norin et al. (1985) found that mean total arsenic residues in freshwater fish near a copper smelter in Sweden ranged from 0.05 to 0.24 mg/kg (wet weight) compared with 0.06 to 0.09 mg/kg for a control lake.

Cockell and Hilton (1988) fed rainbow trout (*O. mykiss*) on diets containing As_2O_3 (180-1477 mg As/kg diet) disodium arsenate heptahydrate (DSA) (137-1053 mg As/kg diet) dimethylarsenic acid (DMA) (163-1497 mg As/kg diet) or arsanilic acid (193-1503 mg As/kg) for 8 weeks. For each of the arsenicals investigated, carcass arsenic concentration showed a dose-response relationship to dietary arsenic concentration and exposure rate. At lower levels of exposure (137 mg As/kg diet) dietary DSA yielded the highest mean carcass arsenic concentrations (6.9 mg As/kg), but at higher levels, dietary As_2O_3 (1477 mg As/kg diet) yielded the highest mean residues (21.6 mg As/kg). Inorganic arsenicals were accumulated from the diet to a greater degree than the organic forms.

Saiki and May (1988) measured arsenic residues in fish from the San Joaquin Valley area of California (USA) exposed to agricultural subsurface drainage water. Mean arsenic concentration ranged from 0.18 to 0.44 mg/kg (dry weight) (maximum value 0.97 mg/kg) for bluegill sunfish (*Lepomis macrochirus*) and from 0.23 to 0.39 mg/kg (maximum value 1.5 mg/kg) for common carp (*Cyprinus carpio*).

Schmitt and Brumbaugh (1990) monitored arsenic residues in freshwater fish in the USA over a period of approximately 10 years. The geometric means (mg/kg wet weight) with the range of parentheses, of total arsenic concentrations were 0.27 (0.05-2.92) during 1976-77, 0.14 (0.05-1.69) during 1980-81 and 0.14 (0.27-1.5) during 1981.

Cockell et al. (1991) studied that dietary DSA (8-174 mg As/kg diet) accumulated in the carcass (0.25-5.7 mg As/kg), liver (0.7-34.4 mg/kg) and kidney (1.1-31.9 mg As/kg) in a dose related manner.

Attar et al. (1992) determined level of total arsenic in muscle tissue of 13 species of finfish from the Arabian Gulf. The range was 0.16-32.3 µg/kg wet wt. for finfish. The levels ranked among the highest reported in the literature and are of potential hazard to human health.

Navarro et al. (1992) analysed 32 locally consumed fish species from the coast of the province of Granada, Spain. The concentration of arsenic in fish ranged from 0.39 to 45.716 µg/gm.

Doganoc (1995) analysed the concentration levels of arsenic in fresh water fishes from the Slovenian rivers and marine fishes from the Adriatic Sea. The following fresh water fishes were analysed : trouts, carps, nases, chubs, barbels, grasscarps and gray lings. Trouts contained between < 0.05 and 1.66 mg/kg As. Among the marine fishes, sardels contained arsenic between 0.48 and 4.44 mg/kg. On the basis of arsenic content in muscle tissue of 139 fishes it was established that the majority of samples corresponded with the permitted tolerance for arsenic in fishes.

Sapunar et al. (1997) determined arsenic level in fish and fishery products, sold in Croatia over a period of 5 year period. The concentration were 498 µg/kg and 270 µg/kg respectively.

Engman and Jorhem (1998) reported arsenic residue in marine fish muscle ranging from 0.59 to 17 mg/kg (fresh weight) with a mean value of 4.5 mg/kg. The mean value was 60 times greater than that found for freshwater fish in the same study.

Takatsu and Uchiumi (1998) analysed fish from a naturally acidified volcanic lake (Lake Usoriko, Japan). Mean arsenic levels were 0.28 and 0.27 mg/kg (wet weight) for gills and bone respectively and 6.1 mg/kg for eye tissue.

Xu-XiaoQing et al. (1998) studied arsenic levels in carp in lakes, reservoir and rivers in Hunan Province in China. They found that carp in lakes and reservoirs had lower levels than in rivers for arsenic.

Bilgili et al. (1999) investigated pollution caused by arsenic residues in grey mullet (*Chalcarburnus tarichii*, Pallas 1811) livers in lake of Van Lake. In 120 fish samples arsenic residues were determined as 0.009-0.347 ppm (average 0.051 ± 0.046). In the light of calculating these results as the arsenic residues in grey mullets occurred by the reflection of terrestrial pollution was below the level of 10 ppm that was the proclaimed limitations. It was concluded that there is no arsenic intoxication risk for human health..

Lin et al. (2001) studied the bioaccumulation of As in *Liza macrolepis* to asses the potential hazards of As to human health. Water samples were collected from 8 fish ponds in the blackfoot diseases area in Taiwan. The average As concentration in 8 culture farms was 79.9 ± 60.6 µg/litre. Analysis of eleven *L. macrolepis* showed that dorsal muscle, abdominal muscle, gill and liver contained an As concentration of 2.24 ± 1.75 , 2.57 ± 2.4 , 2.25 ± 0.87 and 2.05 ± 0.93 mg/gm respectively. The average As concentration in the fish body was 2.35 ± 0.93 µg/g.

Svobodova et al. (2002) assessed the content of arsenic in market ready rainbow trout (*Oncorhynchus mykiss*) from 8 trout farms in the (Czech. Republic. In case of two trout farm the arsenic content recorded exceeded the hygienic limit of 1 mg/kg valid for freshwater fish.

2.9. Arsenic in egg :

Haeghele and Tucker (1974) dosed female mallards (*Anas platyrhynchos*) with a single oral dose of 100 mg sodium arsenite/kg

body weight. Egg shell thickness was reduced within 3 days but had recovered to normal 5 days after dosing. The authors suggested that this temporary reduction in egg shell thickness could be caused by a decrease in food consumption, however, food consumption was not monitored during the test.

Daghir and Hariri (1977) administered arsenilic acid to white Leghorn laying hens at 50 and 100 mg/kg for 15 weeks. Maximum concentration in eggs were reached after 4-5 weeks at 0.13 and 0.24 mg As/kg (dry weight) for the two dose levels respectively.

Donoghue *et al.* (1994) observed that after giving arsenic acid roxarsone (nitro phenyl arsonic acid) as a growth promoters to laying hens at elemental arsenic concentration of 14, 28, 56 and 112 mg/kg diet for 10- weeks, arsenic residues in egg yolk and albumin increased dose dependently although the amount of As was much higher (95% of total) in yolk. Hens treated with As 112 mg/kg from arsenilic acid produced eggs with As residues exceeding Food and Drug Administration whole egg tolerance level (500 ppb).

Zmudzki and Szokoda (1996) examined 455 hen eggs from farms with different rearing and feeding system from 47 polish provinces. The highest level of arsenic was 0.090 mg/kg. They concluded that there was no clear tendency of an accumulation of arsenic in hen eggs. It is also concluded that there was only small differences in the concentration of toxic element in egg between provinces with different degree of pollution.

Holcman and Stibilz (1997) estimated As in egg whites and yolks with increasing As levels in poultry feeds, its concentration in egg yolk and whites also increased, but a plateau appears to be reached quite rapidly. The ratio between As in the yolk and in the egg white was nearly constant (3:1 dry weight basis) irrespective of feed As level.

2.10. Arsenic in milk :

There are only a few reports on the excretion of arsenic in the milk of animals.

Peoples (1964) reported the arsenic level in cow's milk did not increase with the blood concentration when the cows were fed methylarsonic acid or dimethylarsinic acid at the daily dose of 0.03-0.66 mg/kg body weight for 8 weeks.

Calvert (1973) found that the milk arsenic levels increased when cows were fed arsanilic acid or 3-nitro-4-hydroxyphenylarsonic acid (1.6-3.2 mg/kg body weight).

de Navarro (1976) found there was a very drastic reduction in milk production following an outbreak of arsenic poisoning in cattle in Mexico caused by the ingestion of feed containing up to 0.28% arsenic. Levels of up to 0.5 mg As/litre were found in the milk of cows still producing it. In view of the high exposure, these levels of arsenic in milk indicate that arsenic ingested in the form of inorganic arsenic does not readily pass the blood-mammary barrier.

Cervera (1994) determined the arsenic content of cow milk consumed in Spain. The extremely low arsenic levels did not present only toxicological problem.

Rosas *et al.* (1999) determined arsenic levels in fifty samples of cow's milk collected at the most important dairy farms of Comaraca Lagunera, Mexico, a region naturally rich in As. Arsenic concentration found in milk ranged from < 0.9 to 27.4 ng/g. It was associated with the exposure not only to food but also to water arsenic.

2.11. Variation of arsenic residue with species of animal :

In a review, **Doyle and Spaulding (1978)** showed arsenic level in some edible tissues such as liver, kidney and muscle of cattle, sheep, swine and chickens. Concentration of arsenic in liver and kidney appeared very low for all species except chickens.

Falandysz (1988) reported the concentration of arsenic compounds in Baltic fishes ranged from 130 to 5100 µg/kg weight and depended on fish species.

2.12. Variation of arsenic with age :

Kirova (1994) studied the content of arsenic in the musculature and the internal organs of fish from lead and zinc contaminated basins. It has been established that the element increases with the advanced age of fish.

Raie (1996) compared tissue arsenic levels in infants (1 day - 5 months) and adults from the Glasgow (Scotland, UK) area. Mean levels of arsenic (µg/g dry weight) in liver, lung and spleen in infants Vs. adult were 0.0099 Vs. 0.048, 0.007 Vs. 0.044 and 0.0049 Vs. 0.015 respectively. These data suggest that arsenic accumulates in tissues with age, which is consistent with observations in laboratory animals (**Marafante et al., 1982**).

In the most recent study **Yamauchi et al. (1999)** reported that for low age persons the methylation capacity (second methylation i.e. MMA to DMA) were higher than the senior persons. As the retention of arsenic seemed to increase with decreasing methylation efficiency the results indicate that adults retain more arsenic than children and thus, may be more susceptible to arsenic toxicity.

2.13. Variation of arsenic residue with sex :

In a study of human exposure to arsenic via drinking water (upto 600 µg/l) in northeastern Taiwan **Hsu et al. (1997)** indicated that woman had a somewhat higher percentage of DMA and lower percentage of MMA in the urine than man. As the retention of arsenic

supposed to increase with decreasing methylation efficiency (second methylation i.e. MMA to DMA) the results showed that male retain more arsenic than female. In this connection it is also interest to note that **Concha et al. (1998)** reported significant increases in the percentage of DMA excreted in urine during pregnancy which is one possible reason for hormonal effects.

Donaldson and Braune (1999) collected liver tissue adult from American white pelicans (*Pelicanus erythrorhyncos*) on the shore of Lake Winnipeg, Canada and they observed that male livers contained higher concentration of arsenic compared to females. Differences in residue levels between sexes were probably due to the female's ability to excrete the element into the egg prior to laying.

Miranda et al. (2000) conducted a experiment to evaluate the effect of sex on the accumulation of arsenic and other minerals in calves. In case of arsenic no significant statistical differences between males and females were found.

2.14. Clinical symptoms and pathomorphology :

Von glahn et al. (1938) observed liver cirrhosis and necrosis as well as bile duct proliferation in rabbits after administration of arsenate mixing in feed in daily doses of 1.4-9.3 mg per animal for 50-250 days.

Fairhall and Miller (1941) reported that when rats were exposed to calcium and lead arsenate in daily doses of 2 gm/animal in food for 2 years showed casts in the straight collecting tubules and swollen cells with large vesicular nuclei in groups of convoluted tubules of kidney.

Prier et al. (1963) reported that in chronic oral toxicity study with 3-nitro-4-hydroxy phenyl arsonic acid for 2 years in rats, there was decreased rate of growth and deaths were primarily due to

chronic respiratory involvement. Gross pulmonary alterations were observed in rats of either sex. Histopathological examinations revealed bronchiectasis, pneumonia, laryngotracheitis and metaplasia of bronchial epithelium. He suggested that it may be as a result of constant irritation due to retained secretions resulting extensive bronchiectasis. In kidney there were significant alteration consisting of dilation of cortical and medullary tubules varying widely in degree and the dilated tubules containing hyaline casts. In glomeruli, there was degenerative and cystic alteration. The chronic inflammatory cell infiltration and fibrosis was observed.

Byron et al. (1967) reported in rat after administration of sodium arsenate (@, 400 ppm) or arsenite (@, 250 ppm) in a feed for 2 years that there was weight depression. The histopathological examination revealed that there were granulomatous lesions, necrotic tissue debris, small intrahepatic bile ducts and a small pigmented small granules within tubular epithelium and in the lumen of tubules of the kidney cortex.

Carmignani et al. (1983) observed minor histopathological alterations in kidney and liver in rats exposed to sodium arsenate (50 µg As/ml) for 320 days in drinking water. These alterations were characterized by focal changes in the glomerulus and tubules of the kidney and swollen hepatocytes localized near the centrilobular vein.

Hatch (1984) reported that there were intensive inflammation of the proventriculus and gizzard, along with sloughing of the horny lining of the gizzard and reddening of the duodenal mucosa of fowl due to arsenic toxicity. In flow microscopical examination revealed capillary degeneration of gut, skin, lungs and other organs. The degenerative changes ranging from cloudy swelling to necrosis were seen in the gut mucosa, liver, kidney and heart. The degenerative changes might be due to secondary to metabolic and vascular effect of arsenic. Regarding pathogenesis of arsenic, he also reported that arsenic has a local corrosive action on gut regardless of route of

absorption of arsenic. Arsenic has an affinity for tissues rich in oxidative enzymes such as intestine, kidney and liver. Capillary endothelial cells of these organs are sensitive to trivalent arsenic. The primary effect of trivalent arsenic is a relaxation of capillaries and an increase in capillary permeability. The smooth muscle of blood vessels dilates. The G.I. mucosa sloughs away due to accumulation of fluid in the sub-mucosa. The combined metabolic and vascular effects of arsenic explain the cause of pathological changes in different organs.

Shapiro et al. (1992) reported that there was toxic necrotizing cholangiohepatitis in approximately 35% of a flock of 23000 broiler chickens. Affected chicks were small and had discrete green foci through out the liver. The 3-nitro-4-hydroxy phenyl arsonic acid was inadvertently incorporated at ten times the recommended level. Histopathological examination revealed that there was marked dilatation of intrahepatic bile ducts, patchy necrosis and hyperplasia of the bile duct epithelium.

Biswas et al. (2000) observed that goats, induced with sodium arsenite (@ 25 mg/kg body weight) for 12 weeks developed clinical signs of toxicity consisting of gastrointestinal disturbances and renal insufficiency. Pathomorphological changes showed enlargement of the kidneys, abomasum and liver with greyish white necrotic foci on the surfaces. The intestinal mucosa, kidneys and spleen were haemorrhagic in varying degree. The histopathological lesions comprised moderate to severe hyperemia and haemorrhages in the in the intestinal mucosa, kidneys and spleen. The cytotoxic lesions were cellular swelling with granular cytoplasm, degeneration and/or coagulative necrosis in hepatocytes, epithelium of abomasum and intestinal mucosa, the tubular epithelium of kidney and lymphoid cells in the Malpighian corpuscles of spleen.

CHAPTER III

MATERIALS AND METHODS

Urine and milk samples were collected in prewashed polythene bottles.

The samples were not subjected to any chemical treatment and carried in ice box and in the laboratory they were kept in deep freeze (-20°C) until analysis were carried out.

Blood samples were taken from the vein using stainless steel needle and transferred into pre-acid washed polythene containers containing heparin as an anticoagulant. The blood samples were carried in ice-box and kept at -20°C until analyzed.

3.2.2. Sample treatment

3.2.2.1. Surface water and Urine :

Prior to analysis, the surface water (pond) and urine samples were centrifuged at 3000 rpm for 10 min. and filtered through a 0.45 µm membrane filter to remove the suspended particles.

3.2.2.2. Hair / Feather :

Hair or feather samples were collected from by using a ceramic blade cutter. First the samples were washed with triple distilled de-ionized water and finally with acetone as recommended by the International Atomic Energy Agency (1976). It was dried in an oven at a temperature of 50-60°C. Thereafter the samples were digested.

3.2.2.3. Claw / Hoof :

Claw or hoofs were also collected by ceramic blade cutter. After collection they were thoroughly washed with double distilled water and finally with acetone. The samples were then checked under a magnifying glass for any adhering material and dried at 50-60°C temperature.

3.2.3. Digestion of samples by wet oxidation procedure :

Destruction of organic matter is an important part of the determination of arsenic in biological samples. To inhibit the volatilization of arsenic and to destroy the organic matter combined

43% shallow tube wells are having arsenic level above 0.05 mg/l in Deganga block (Mandal *et al.*, 1997). Based on this report Deganga block has been considered as an arsenic affected block during sample collection.

In the block Deganga North 24 Parganas the sampling was conducted in the following purposively selected villages of two selected Gram Panchayet considering the availability of comparatively high level of arsenic residue in different elements of environment.

Name of Gram Panchayet	Village
1. Kolsur	i) Uttar Kolsur ii) Kamdebkati iii) Raniati
2. Hadipur Jhikra - I	i) Shanpukur ii) Singerati iii) Jhikra

Considering the availability of normal level of arsenic random sampling was conducted in one selected Gram Panchayet of Debra block in Paschim Midnapore as control area.

Name of Gram Panchayet	Village
1. Golgram	i) Golgram ii) Kanchanpur iii) Bhagirathpur

All the parameters (age, sex, etc.) under the study irrespective of any farmers are homogenous in characteristics. The farmers have been identified selectively and randomly keeping in view that all the parameters under study should have with them. Further it has been considered during selection that all the terrestrial and aquatic animals under study have reared under same nutritional and managerial practices.

3.1.2 Selection of elements :

The categorywise distribution of the elements have been below :

Table 1

Selected element	Control G.P.	Affected G.P.		Total
		Kulsur	Hadipur-Jhikara - I	
Ground Water	3	30	30	63
Surface Water				
a) Top surface water	3	30	30	63
b) Bottom surface water	3	30	30	63
Total no. of water	9	90	90	189
Sediment	3	10	10	23
Soil	3	15	15	33
Forage & Plants				
a) Paddy Straw	3	5	5	13
b) Field grass	3	5	5	13
c) Jack fruit leaf	3	5	5	13
d) Banyan leaf	3	5	5	13
e) Banana	3	5	5	13
f) Bamboo	3	5	5	13
g) Vegetable waste	3	5	5	13
Total No. of forage & plant samples	21	35	35	91
Birds				
a) Reared in Intensive system (Broiler)				
Age				
i) 25 - 30 days	3	5	5	13
ii) 40 - 50 days	3	5	5	13
Total No. of broilers	6	10	10	26
b) Reared in Free range system (Desi Bird)				
Sex				
1) Hen				
Age				
i) Upto 22 weeks	3	5	5	13
ii) > 22 weeks	3	5	5	13
2) Cock				
Age				

i) Upto 22 weeks	3	5	5	13
Selected element	Control	Affected G.P.		Total
	G.P.	Kulsur	Hadipur-Jhikara - I	
ii) > 22 weeks	3	5	5	13
Total No. of Desi birds	12	20	20	52
Total No. of birds	18	30	30	78
Bengal goat				
Sex				
1) Buck				
Age				
i) upto 2years	3	5	5	13
ii) > 2 years	3	5	5	13
2) Castrated (<i>Wether</i>)				
Age				
i) upto 2 years	3	5	5	13
ii) > 2 years	3	5	5	13
3) Doe				
Age				
i) upto 2 years	3	5	5	13
ii) > 2 years	3	5	5	13
Total No. of goats	18	30	30	78
Fish				
a) Common carp				
Age				
i) upto 6 month	3	5	5	13
ii) > 6 month	3	5	5	13
Total No. of				
Common Carp	6	10	10	26
b) Rohu				
Age				
i) upto 6 month	3	5	5	13
ii) > 6 month	3	5	5	13
Total No. of Rohu	6	10	10	26
c) Catla				
Age				
i) upto 6 month	3	5	5	13

ii) > 6 month	3	5	5	13
Total No. of Catla	6	10	10	26
Total No. of fish	18	30	30	78
Egg	3	20	20	43
Milk				
a) Goat milk	3	30	30	63
b) Cow milk	3	30	30	63
Total No. of milk sample	6	60	60	120
Total selected Elements	99	320	320	739

3.1.3. Selection of sub-elements :

In animals, fishes and eggs the following sub elements were taken for estimation of arsenic level

Table - 2

Element

Item procured for estimation

Bird

Thigh muscle, Breast muscle, Fat, Liver, Kidney, Heart, Lung, Spleen, Bone, Proventriculus, Gizzard, Intestine, Feather, Claw, Brain, Whole Blood, Plasma, Blood cell, Reproductive organs (in desi bird), Faeces and Meat* (Chicken).

Goat

Thigh muscle, Breast muscle, Fat, Liver, Kidney, Heart, Lung, Spleen, Bone, ~~Abomasum~~, Intestine, Hair, Hoof, Skin, Brain, Whole blood, Plasma, Blood cell, Reproductive organs, Urine, Faeces and Meat** (Chevon).

Fish

Dorsal muscle, Abdominal muscle, Liver, Kidney, Heart, Gill, Spleen,

Eye, Scale, Fin, Whole blood and Fish flesh***.

Egg Whole egg, Yolk, Egg albumin, Egg shell.

Meat* (Chicken) included Thigh muscles, Breast muscles, Fat and Giblets (i.e. Liver, Gizzard, Heart) which is pooled meat sample.

Meat** (Chevon) included Thigh muscles, Breast muscles, Fat, Liver, Kidney, Heart and Brain which is pooled meat sample.

Fish flesh*** included Dorshal and Abdominal muscle which is pooled fish flesh sample.

3.2. Estimation of total arsenic level

3.2.1. Collection of samples :

Care was taken to avoid contamination during sample collection and storage. The instruments and glass wares used to handle and store the tissue were chemically cleaned, rinsed in triple distilled deionized water and air dried.

3.2.1.1. Water collection and preservation :

Polythene bottles were prewashed with nitric acid (1+1), and after collection, nitric acid (0.1% v/v) was added to preserve the oxidation state of arsenic compounds in water.

3.2.1.2. Collection and preservation of sample other than water :

The tissues & faeces, were collected in polythene zipper bag and carried in ice box within 2 hrs. in laboratory and were kept in deep freeze (-20°C) until analysed.

The soil, feeds were collected in polythene zipper bag and in laboratory these were kept in 4°C, collected eggs were also kept in 4°C until analysed.

acids are required. The oxidation potential of the HNO_3 - H_2SO_4 - HClO_4 combination is high enough to decompose organic matter completely at temperatures about $< 200^\circ\text{C}$ (Maher, 1983). 3 gm soil, sediments, feeds, fodder and faeces were digested with triple acid i.e. HNO_3 - H_2SO_4 - HClO_4 in the ratio of 6: 4 : 1 v/v. 3 g or 3 ml (wet weight) biological samples were digested in triple acid mixture i.e. HNO_3 - H_2SO_4 - HClO_4 in the ratio of 9 : 2 : 1 v/v. Dilution to a known volume (10 ml) was finally made with triple-distilled deionized water. (AOAC, 1980). This solution was passed through a filter paper and the filtrate was measured for arsenic.

Spectrophotometry using the silver diethyldithiocarbamate complex of arsine is the classical method for determining arsenic (Vasak and Sedivec, 1952). Here the above mentioned method has been adopted.

3.2.4. Principle :

Treating the arsenic solution with concentrated hydrochloric acid, potassium iodide and stannous chloride, the arsenic is reduced to trivalent state. After addition of zinc, hydrogen is liberated and reacts with arsenic and form arsine gas (AsH_3). Arsine reacts with a solution of silver diethyldithiocarbamate (SDDC) in pyridine to form a soluble red complex suitable for photometric method.

3.2.5. Apparatus :

a) Arsine generator (Gutzeit generator), Scrubber and absorption tube :

With slight modifications, it consists of one generator flask which has a capacity of 250 ml, scrubber and arsine absorber. The generator flask is connected to scrubber with a standard joint and scrubber is then attached to arsine absorber with standard joint.

b) Photometric equipment :

UV spectrophotometer with 1 cm cells.

3.2.6. Reagents :

a) Triple distilled deionized water

- b) Triple acid mixture : Concentrated nitric acid (HNO_3), 70% Perchloric acid (HClO_4), sulfuric acid (H_2SO_4).
- c) Concentrated hydrochloric acid.
- d) Potassium iodide solution : 15 g potassium iodide was dissolved in 100 ml distilled water and stored in a brown bottle.
- e) Stannous chloride reagent : 40 g arsenic free A.R. hydrated stannous chloride ($\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$) was dissolved in 100 ml concentrated hydrochloric acid.
- f) Lead acetate solution : 10 g. lead acetate [$\text{Pb}(\text{CH}_3\text{COO})_2 \cdot 3\text{H}_2\text{O}$] in 100 ml distilled water.
- g) Silver diethyldithiocarbamate reagent: 1 g silverdiethyldithiocarbamate [$\text{Ag SCSN}(\text{C}_2\text{H}_5)_2$] in 200 ml pyridine and stored in brown bottle.
- h) Zinc, 20 to 30 mesh, arsenic free.
- i) Stock arsenic solution : 1.320 g arsenic trioxide (As_2O_3) was dissolved in 10 ml distilled water containing 4 g. NaOH and diluted to 1000 ml with distilled water. 1 ml = 1 mg As.
- j) Intermediate arsenic solution: 5 ml stock solution was diluted to 500 ml with distilled water. 1 ml = 10 μg As.
- k) Standard arsenic solution: 10 ml intermediate solution was diluted to 100 ml with distilled water. 1 ml = 1 μg As.

3.2.7. Preparation of a standard curve

3.2.7.1. Treatment of samples :

Standard arsenic solution was pipetted in to a series of clear generator flasks. Covering the range 0 to 10 μg of arsenic. To each of these flasks distilled water was added and the volume was made upto 35 ml. Then in each flask 5 ml of concentrated hydrochloric acid, 2 ml

of 15% potassium iodide solution and 8 drops (0.40 ml) of 40% stannous chloride solution were added. The content of the flasks were mixed properly and 15 minutes time was allowed for these flask to ensure complete reduction of arsenic to the trivalent state.

3.2.7.2. Preparation of scrubber and absorber :

Some cotton plug was soaked with 10% lead acetate solution and introduced into scrubber. In arsine absorber, 4 ml of SDDC with pyridine solution was pipetted.

3.2.7.3. Arsine generation and measurement :

To each generator 4 g zinc was added and scrubber absorber assembly was connected immediately.

The evolution of arsine was complete in 30 mins. The generator was warmed slightly to insure that all arsine was released. Then the solution was transferred from absorber directly into 1 cm cell and optical density of each solution was plotted against its arsenic content in μg . Thus a standard curve or calibration curve was made.

Digestion : Digestion was done in the Tecator digester attached with a condenser at the temperature below 200°C .

3.2.8. Determination of total arsenic in sample :

For actual determination of total arsenic in various sample solution, the same procedure as for the calibration curve was followed, one for the reagent blank and others for the sample solutions.

From optical density measured at 535 nm the arsenic content of the sample solution was obtained by reference to the calibration graph.

$$\text{mg As/l or } \mu\text{g} = \frac{\mu\text{g As (from calibration curve)}}{\text{ml or g sample in generator flask}}$$

3.2.9. Recovery of arsenic trioxide added to different biological sample before wet oxidation :

3 grams of accurately weighed fresh liver homogenates were taken in each digestion tube, ^{and arsenic} trioxide solution containing 1 µg/ml was added to these tubes at different level covering the range 0 - 10 µg of arsenic. Then the wet oxidation procedure as stated previously was followed. After completion of wet oxidation, the solution was measured for arsenic concentration and plotted. From the calibration curve, the amount of total arsenic in µg was determined for each solution and recovery of added arsenic trioxide was calculated.

This method like liver tissue was also applied in other biological samples and the recovery of arsenic trioxide added to those tissues was measured.

Complete recovery of added arsenic was not obtained but the percentage of recovery of arsenic trioxide to different samples ranged from 86 to 92%. Arsenic concentrations were expressed in wet weight basis.

3.3. Pathomorphological examination of selected samples:

In most of the animals the symptoms were in subclinical stage. Very few animals particularly birds were showing symptoms of arsenicosis. For pathomorphological studies samples were taken from suspected cases of arsenicosis manifesting the symptoms. For histopathological studies lungs, liver, heart, proventriculus, gizzard, intestine, spleen, kidney, uterus and ovary/testis were taken.

Specimens having the active lesions were fixed in 10% neutral buffered formalin and processed for paraffin sectioning (5 µm thickness) and stained with Mayer's Haematoxylin and Eosin (H & E) staining procedure as adopted by Lillie (1965).

3.4. Statistical Methods :

The statistical methods used in the present study were Mean with Standard error and t-test as outlined by Snedecor and Cochran (1967).

CHAPTER IV

RESULTS AND DISCUSSION

Results and Discussion

The present study was undertaken to exhibit an idea about the arsenic profile in the different elements of environment and the contribution of arsenic from animal and fish products to the human health. Data so collected are presented in the tables (Table 3 to Table 36) discussed as follows :

4.1. Arsenic profile in different elements of environment :

The arsenic profile in different elements like ground water, surface water (pond), pond sediment, soil, paddy straw, field grass, different tree leaves and vegetable waste of Golgram (control) G.P. of same block in Paschim Midnapore, Kolsur G.P. and Hadipur-Jhikra-I G.P. of Deganga Block in North 24 Parganas are presented in Table 3.

4.1.1. Concentration of arsenic in water

4.1.1.1. Concentration of arsenic in ground water :

Thirty samples of ground water from each of Kolsur and Hadipur-Jhikra-I Gram Panchayet and 3 samples of ground water from Golgram Gram Panchayet were tested for the arsenic content and it was found that average arsenic content (in mg/l) of ground water were 0.3828 ± 0.0687 , 0.1636 ± 0.0328 and 0.0020 ± 0.0006 respectively. The ground water arsenic content of both the affected G.P. was not only more than the ground water arsenic content of unaffected (control) G.P. but also beyond the permissible limit of 0.05 mg/l (WHO, 1984).

Mandal *et al.* (1997) reported that 40% hand tubewells and 43% shallow tubewells of Deganga block were having arsenic level above

Table . 3. Mean $\pm$ SE of concentration of arsenic in water pond sediment, soil, feed, fodder and different tree leaves (mg/kg or mg/l)

ELEMENT		GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Ground water		0.0020 $\pm$ 0.0006	0.3828 $\pm$ 0.0687	0.1636 $\pm$ 0.0328
Surface water (pond)	Top water	0.0013 $\pm$ 0.0003	0.0968 $\pm$ 0.0274	0.0584 $\pm$ 0.0057
	Bottom water	0.0017 $\pm$ 0.0007	0.1031 $\pm$ 0.0094	0.0893 $\pm$ 0.0101
Pond sediment		5.3340 $\pm$ 0.3517	28.2525 $\pm$ 2.5038	20.9197 $\pm$ 1.8736
Soil		5.9907 $\pm$ 0.5256	32.2838 $\pm$ 1.8467	29.5293 $\pm$ 1.7225
Feed		0.1557 $\pm$ 0.0171	0.1518 $\pm$ 0.0192	0.2008 $\pm$ 0.0162
Paddy straw		0.2130 $\pm$ 0.0098	2.3108 $\pm$ 0.2216	1.7764 $\pm$ 0.1436
Field grass		0.1790 $\pm$ 0.0102	1.6804 $\pm$ 0.2371	1.2690 $\pm$ 0.1883
Jackfruit leaf		0.0063 $\pm$ 0.0009	0.7564 $\pm$ 0.0678	0.5554 $\pm$ 0.0787
Banyan leaf		0.0100 $\pm$ 0.0012	1.0912 $\pm$ 0.1499	0.7516 $\pm$ 0.1317
Banana leaf		0.0080 $\pm$ 0.0038	1.3956 $\pm$ 0.1681	0.7904 $\pm$ 0.1288
Bamboo leaf		0.0113 $\pm$ 0.0009	1.3786 $\pm$ 0.1441	0.7902 $\pm$ 0.1282
Vegetable waste		0.0123 $\pm$ 0.0022	1.7304 $\pm$ 0.2374	1.3682 $\pm$ 0.1981

0.05 mg/l This observation was corroborated with the findings of the present study.

4.1.1.2. Concentration of arsenic in surface water (Pond) :

Table 3 showed the arsenic content of surface water. 30 samples from each of top and bottom layer of ponds of affected G.P. as well as 3 samples from unaffected G.P. were collected to estimate total arsenic content. From the average data, it was cleared that arsenic content of both layers of pond of affected G.P. were more than the average value of unaffected G.P. Apparently it was found that water of bottom layer contained more arsenic than the top layer and arsenic content of both layers were found to be more than the permissible limit but surface water of both layers contained arsenic level lower than the level of arsenic in ground water of same area. Present finding supported the result reported by Bokori and Gyori (1989) where they also observed similar type of results.

4.1.2. Concentration of arsenic in Pond sediment :

Golgram, Kolsur and Hadipur-Jhikra-I G.P. (Table 3) showed mean total arsenic concentration (mg/kg) in pond sediment as the level of 5.3340 ± 0.3517 , 28.2525 ± 2.5038 and 20.9197 ± 1.8736 respectively. It was found that sediment concentration of arsenic in all the G.P.s were higher than the value of surface water because sediment adsorption of arsenic was positively correlated with clay/humus content of pond sediment (Wauchope and McDowell, 1984). The present finding was corroborated with the report of Welch *et al.*, (1988).

4.1.3. Concentration of arsenic in soil :

In the present study, mean arsenic content (mg/kg) of Golgram, Kolsur and Hadipur-Jhikra-I G.P. were found to be 5.9907 ± 0.5256 ,

32.2838 $\pm$ 1.8467 and 29.5293 $\pm$ 1.7225 respectively. These values correlated with the observation of Takamatsu *et al.* (1982) who recorded mean total arsenic concentration of agricultural soils as the value of 50-60 mg/kg. Soil arsenic content of both the affected G.P. showed higher value than the unaffected G.P. may be due to higher arsenic contaminated irrigation water (Ghosh *et al.*, 2002).

4.1.4. Concentration of arsenic in feed, fodder and tree leaves :

Mean total arsenic content of paddy straw, field grass, jackfruit leaf, banyan leaf, banana leaf, bamboo leaf, vegetable wastes and concentrate feed of three G.P. were presented in Table 3. In all the cases there was a positive correlation between arsenic level of fodder or tree leaves and soil. Soil containing higher arsenic level reflected the higher values in fodder and tree leaves, indicating soil plant interrelationship of arsenic. Present findings correlated the observation of Merry *et al.* (1986) who reported that pasture plant contained arsenic 2.5 mg/kg where soil concentration of arsenic was 80 mg/kg. Concentrate feed showed lesser value of arsenic than fodder and tree leaves indicated that there was no positive correlation between arsenic content of soil and concentrate feed possibly may be due to collection of that feed ingredients for concentrates from the places other than the affected area.

4.1.5. Concentration of arsenic in different tissues and excreta of animals

4.1.5.1. Concentration of arsenic in different body parts, organs, blood and excreta of broiler birds :

The mean values of arsenic concentration with standard error in different tissues and excreta of broiler bird in different age group were

shown in Table 4 and Table 5 respectively. In the age group of 25-30 days, the arsenic concentration was highest in the Claw followed by Feather, Skin, Liver, Kidney, Lung, Intestine, Gizzard, Proventriculus, Spleen, Heart, Bone, Thigh, Breast, Fat, Blood cell, Whole blood and Plasma. Whereas, in the age group of 40-50 days the concentration of arsenic in different tissues were in the following descending order- Claw, Feather, Skin, Liver, Kidney, Lung, Intestine, Bone, Gizzard, Proventriculus, Spleen, Heart, Thigh, Breast, Fat, Blood cell, Whole blood and Plasma.

In both the ages, among edible parts other than the Skin, Liver contained the highest concentration of arsenic which was also observed by Proudfoot *et al.* (1991).

Data revealed that the deposition of arsenic in organs was more in early ages in compared to deposition in bones but with the advancement of age the reverse observation in relation to deposition was also noticed in majority of cases.

It was found that in all the cases thigh muscle contained higher values of arsenic than that of breast muscle possibly might be due to the more blood circulation to thigh muscle which caused more deposition of arsenic in that part of the body. Like the present findings, Proudfoot *et al.* (1991) also found a significant differences between thigh and breast muscle. The residue level of arsenic in breast muscle was 60% or more lower than that of thigh muscle.

Among the different components of blood, plasma showed lowest value whereas blood cells contained highest value of arsenic and its intermediate value was found in whole blood. This observation indicated that blood cell has a tendency to accumulate more arsenic. The present finding supported the report of WHO (1981), where it was shown that the whole blood arsenic level contained two times than the plasma level and red cells contained about 3 times more arsenic than the plasma.

Table . 4. Mean $\pm$ SE of concentration of arsenic in different body parts, organs, blood and excreta of broiler bird, 25-30 days old (mg/kg or mg/l)

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0250 $\pm$ 0.0023	0.4628 $\pm$ 0.0105	0.3754 $\pm$ 0.0101
Breast muscle	0.0110 $\pm$ 0.0015	0.2146 $\pm$ 0.0070	0.1744 $\pm$ 0.0054
Fat	0.0037 $\pm$ 0.0009	0.1124 $\pm$ 0.0041	0.0822 $\pm$ 0.0011
Liver	0.0470 $\pm$ 0.0021	0.9246 $\pm$ 0.0620	0.7624 $\pm$ 0.0487
Kidney	0.0430 $\pm$ 0.0015	0.8130 $\pm$ 0.0534	0.6144 $\pm$ 0.0250
Heart	0.0269 $\pm$ 0.0025	0.6064 $\pm$ 0.0069	0.4870 $\pm$ 0.0053
Lung	0.0327 $\pm$ 0.0020	0.7268 $\pm$ 0.0408	0.5786 $\pm$ 0.0319
Spleen	0.0287 $\pm$ 0.0027	0.5946 $\pm$ 0.0190	0.4808 $\pm$ 0.0152
Bone	0.0263 $\pm$ 0.0018	0.5462 $\pm$ 0.2430	0.4404 $\pm$ 0.0197
Proventriculus	0.0293 $\pm$ 0.0027	0.6176 $\pm$ 0.0167	0.5002 $\pm$ 0.0138
Gizzard	0.0297 $\pm$ 0.0026	0.6630 $\pm$ 0.0288	0.5476 $\pm$ 0.0349
Intestine	0.0317 $\pm$ 0.0012	0.6860 $\pm$ 0.0343	0.5716 $\pm$ 0.0386
Feather	0.2543 $\pm$ 0.0136	2.2866 $\pm$ 0.2347	1.9632 $\pm$ 0.1740
Claw	0.2793 $\pm$ 0.0177	3.2996 $\pm$ 0.1545	2.2194 $\pm$ 0.3139
Skin	0.1240 $\pm$ 0.0116	1.8046 $\pm$ 0.1298	1.3942 $\pm$ 0.1030
Brain	0.0103 $\pm$ 0.0045	0.1874 $\pm$ 0.0057	0.1618 $\pm$ 0.0036
Whole blood	0.0143 $\pm$ 0.0009	0.1046 $\pm$ 0.0159	0.0860 $\pm$ 0.0128
Plasma	0.0063 $\pm$ 0.0009	0.0520 $\pm$ 0.0081	0.0384 $\pm$ 0.0054
Blood cell	0.0187 $\pm$ 0.0012	0.1546 $\pm$ 0.2280	0.1204 $\pm$ 0.0146
Faeces	0.1943 $\pm$ 0.0073	2.0272 $\pm$ 0.1057	1.7130 $\pm$ 0.0588
Meat	0.0240 $\pm$ 0.0060	0.5410 $\pm$ 0.1410	0.4100 $\pm$ 0.1040

Table . 5. Mean $\pm$ SE of concentration of Arsenic in different body parts, organs, blood and excreta of Broiler bird, 40-50 days old (mg/kg or mg/l)

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0377 $\pm$ 0.0022	0.6788 $\pm$ 0.0593	0.5348 $\pm$ 0.0270
Breast muscle	0.0163 $\pm$ 0.0015	0.3264 $\pm$ 0.0195	0.2444 $\pm$ 0.0113
Fat	0.0063 $\pm$ 0.0015	0.1238 $\pm$ 0.0040	0.0882 $\pm$ 0.0037
Liver	0.0777 $\pm$ 0.0059	1.5976 $\pm$ 0.1342	1.2588 $\pm$ 0.1046
Kidney	0.0630 $\pm$ 0.0059	1.4684 $\pm$ 0.1361	1.1412 $\pm$ 0.1329
Heart	0.0440 $\pm$ 0.0029	0.7942 $\pm$ 0.0650	0.6604 $\pm$ 0.0530
Lung	0.0607 $\pm$ 0.0064	1.3448 $\pm$ 0.1265	1.0320 $\pm$ 0.0985
Spleen	0.0563 $\pm$ 0.0049	1.1108 $\pm$ 0.0551	0.8916 $\pm$ 0.0569
Bone	0.0577 $\pm$ 0.0064	1.2988 $\pm$ 0.0886	1.0092 $\pm$ 0.0806
Proventriculus	0.0480 $\pm$ 0.0047	1.1488 $\pm$ 0.0728	0.8862 $\pm$ 0.0685
Gizzard	0.0520 $\pm$ 0.0055	1.1980 $\pm$ 0.0743	0.9546 $\pm$ 0.0804
Intestine	0.0593 $\pm$ 0.0047	1.2542 $\pm$ 0.0820	1.0852 $\pm$ 0.0592
Feather	0.2763 $\pm$ 0.0064	2.5356 $\pm$ 0.2269	2.1648 $\pm$ 0.1952
Claw	0.3076 $\pm$ 0.0164	2.8242 $\pm$ 0.2596	2.4694 $\pm$ 0.3421
Skin	0.1307 $\pm$ 0.0102	2.0760 $\pm$ 0.1203	1.7092 $\pm$ 0.0971
Brain	0.0117 $\pm$ 0.0043	0.2683 $\pm$ 0.0269	0.1998 $\pm$ 0.0234
Whole blood	0.0193 $\pm$ 0.0009	0.0970 $\pm$ 0.0170	0.0798 $\pm$ 0.0102
Plasma	0.0077 $\pm$ 0.0003	0.0470 $\pm$ 0.0080	0.0382 $\pm$ 0.0064
Blood cell	0.0273 $\pm$ 0.0027	0.1404 $\pm$ 0.0252	0.1152 $\pm$ 0.0160
Faeces	0.1860 $\pm$ 0.0051	1.9870 $\pm$ 0.0976	1.5686 $\pm$ 0.0185
Meat	0.0390 $\pm$ 0.0110	0.7870 $\pm$ 0.2230	0.6230 $\pm$ 0.1780

It was found that brain contained lower concentration of arsenic might be due to blood-brain barrier which could not prevent the entry of arsenic completely but made its rate of entry slower (Lindgren *et al.*, 1982).

Feather, claw and skin showed to contain higher values of arsenic than that of other tissues might be because of these body parts contained protein, rich in sulfhydryl group and due to higher affinity of arsenic to sulfhydryl group, more amount of arsenic could be deposited in those parts of the body (Vaheter and Marafante, 1983).

Arsenic concentration (mg/kg) in broiler meat as a whole in Golgram, Kolsur and Hadipur-Jhikra-I were found to be 0.024 ± 0.006 , 0.541 ± 0.141 and 0.410 ± 0.104 in the age group of 25-30 days and 0.039 ± 0.011 , 0.787 ± 0.223 and 0.623 ± 0.178 in the age group of 40-50 days respectively. In both the affected G.P. the meat arsenic concentration were higher in both age group than that of in unaffected G.P. Values in all the affected G.P.s were higher than the permissible level of 0.1 mg/kg (Kreuzer and Logdeser, 1980) but lower than the permissible level of 1 mg/kg (MFPO - Amended in 1992). Though the value was lower than Indian maximum permissible limit but in long term consumption of such contaminated broiler meat might play a significant contributory role along with the contaminated drinking water to cause ailments of human health.

4.1.5.2. Concentration of arsenic in different body parts, organs, blood and excreta of desi bird :

The mean values of arsenic concentration with standard error in different tissues and excreta of desi birds of two age group under each sex, i.e. hen and cock are shown in Table 6, Table 7, Table 8 and Table 9 respectively.

The arsenic content in different tissues were in the following descending order by and large –

Table . 6. Mean $\pm$ SE of concentration of arsenic in different body parts, organs, blood and excreta of desi hen, aged up to 22 weeks (mg/kg or mg/l).

SUB-ELEMENT	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0507 $\pm$ 0.0015	0.6952 $\pm$ 0.0546	0.5466 $\pm$ 0.0311
Breast muscle	0.0223 $\pm$ 0.0009	0.3310 $\pm$ 0.0168	0.2584 $\pm$ 0.0133
Fat	0.0103 $\pm$ 0.0015	0.1270 $\pm$ 0.0081	0.0934 $\pm$ 0.0038
Liver	0.0840 $\pm$ 0.0046	1.6776 $\pm$ 0.1561 $\pm$	1.3196 $\pm$ 0.1214
Kidney	0.0753 $\pm$ 0.0043	1.5486 $\pm$ 0.1388	1.1754 $\pm$ 0.1275
Heart	0.0583 $\pm$ 0.0020	0.8406 $\pm$ 0.0645	0.6726 $\pm$ 0.0500
Lung	0.0700 $\pm$ 0.0046	1.2782 $\pm$ 0.1319	1.0518 $\pm$ 0.1037
Spleen	0.0653 $\pm$ 0.0038	1.1358 $\pm$ 0.0708	0.9040 $\pm$ 0.0520
Bone	0.0797 $\pm$ 0.0035	1.3230 $\pm$ 0.1083	1.0394 $\pm$ 0.0851
Proventriculus	0.0593 $\pm$ 0.0032	1.1948 $\pm$ 0.1025	0.9200 $\pm$ 0.0786
Gizzard	0.0640 $\pm$ 0.0044	1.2500 $\pm$ 0.0946	0.9768 $\pm$ 0.0808
Intestine	0.0693 $\pm$ 0.0046	1.3338 $\pm$ 0.0655	1.1132 $\pm$ 0.0604
Feather	0.2923 $\pm$ 0.0061	2.6956 $\pm$ 0.2440	2.1870 $\pm$ 0.1948
Claw	0.3247 $\pm$ 0.0159	3.2762 $\pm$ 0.4127	2.5258 $\pm$ 0.3513
Skin	0.1463 $\pm$ 0.0069	2.1608 $\pm$ 0.1105	1.7480 $\pm$ 0.0992
Brain	0.0203 $\pm$ 0.0027	0.3028 $\pm$ 0.0337	0.2218 $\pm$ 0.0273
Whole blood	0.0260 $\pm$ 0.0029	0.1014 $\pm$ 0.0181	0.0828 $\pm$ 0.0127
Plasma	0.0110 $\pm$ 0.0012	0.0498 $\pm$ 0.0095	0.0404 $\pm$ 0.0065
Blood cell	0.0370 $\pm$ 0.0038	0.1466 $\pm$ 0.0264	0.1212 $\pm$ 0.0188
Ovary	0.0430 $\pm$ 0.0021	0.4050 $\pm$ 0.0600	0.3426 $\pm$ 0.0613
Faeces	0.1830 $\pm$ 0.0046	1.9528 $\pm$ 0.0886	1.5266 $\pm$ 0.0203
Meat	0.048 $\pm$ 0.011	0.820 $\pm$ 0.235	0.6447 $\pm$ 0.1854

Table . 7. Mean $\pm$ SE of concentration of arsenic in different body parts, organs, blood and excreta of desi hen aged more than 22 weeks (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0547 $\pm$ 0.0023	0.7218 $\pm$ 0.0491	0.5796 $\pm$ 0.0387
Breast muscle	0.0240 $\pm$ 0.0012	0.3342 $\pm$ 0.0179	0.2652 $\pm$ 0.0130
Fat	0.0123 $\pm$ 0.0018	0.1296 $\pm$ 0.0062	0.1020 $\pm$ 0.0048
Liver	0.0907 $\pm$ 0.0043	1.7788 $\pm$ 0.11655	1.3620 $\pm$ 0.1347
Kidney	0.0783 $\pm$ 0.0043	1.6862 $\pm$ 0.1495	1.2288 $\pm$ 0.1251
Heart	0.0613 $\pm$ 0.0023	0.9414 $\pm$ 0.900	0.6882 $\pm$ 0.0508
Lung	0.0763 $\pm$ 0.0050 $\pm$	1.5222 $\pm$ 0.0910	1.0966 $\pm$ 0.1150
Spleen	0.0693 $\pm$ 0.0044	1.1918 $\pm$ 0.0776	0.9188 $\pm$ 0.0495
Bone	0.0863 $\pm$ 0.0009	1.4770 $\pm$ 0.1211	1.1032 $\pm$ 0.0830
Proventriculus	0.0640 $\pm$ 0.0029	1.2442 $\pm$ 0.1046	0.9380 $\pm$ 0.0799
Gizzard	0.0687 $\pm$ 0.0035	1.2570 $\pm$ 0.1110	1.0012 $\pm$ 0.0837
Intestine	0.0753 $\pm$ 0.0046	1.4026 $\pm$ 0.0775	1.1580 $\pm$ 0.0681
Feather	0.3053 $\pm$ 0.0069	2.7426 $\pm$ 0.2540	2.2936 $\pm$ 0.1939
Claw	0.3350 $\pm$ 0.0182	3.4156 $\pm$ 0.4145	2.6326 $\pm$ 0.3734
Skin	0.1543 $\pm$ 0.0074	2.4366 $\pm$ 0.2567	1.8298 $\pm$ 0.0955
Brain	0.0229 $\pm$ 0.0040	0.3230 $\pm$ 0.0390	0.2480 $\pm$ 0.0122
Whole blood	0.0277 $\pm$ 0.0018	0.1054 $\pm$ 0.0169	0.0890 $\pm$ 0.0139
Plasma	0.0123 $\pm$ 0.0009	0.0528 $\pm$ 0.0100	0.0456 $\pm$ 0.0071
Blood cell	0.0377 $\pm$ 0.0049	0.1540 $\pm$ 0.0261	0.1362 $\pm$ 0.0194
Ovary	0.0450 $\pm$ 0.0017	0.5832 $\pm$ 0.0961	0.4398 $\pm$ 0.0835
Faeces	0.1757 $\pm$ 0.0046	1.9216 $\pm$ 0.0821	1.5160 $\pm$ 0.0203
Meat	0.0520 $\pm$ 0.0120	0.8600 $\pm$ 0.2480	0.6663 $\pm$ 0.1901

Table . 8. Mean $\pm$ SE of concentration of arsenic in different body parts, organs, blood and faeces of desi cock, aged up to 22 weeks (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0507 $\pm$ 0.0026	0.6668 $\pm$ 0.0309	0.5460 $\pm$ 0.0297
Breast muscle	0.0230 $\pm$ 0.0017	0.3310 $\pm$ 0.0175	0.2616 $\pm$ 0.0143
Fat	0.0107 $\pm$ 0.0018	0.1278 $\pm$ 0.0086	0.0936 $\pm$ 0.0050
Liver	0.0803 $\pm$ 0.0050	1.6868 $\pm$ 0.1622	1.3256 $\pm$ 0.1185
Kidney	0.0727 $\pm$ 0.0058	1.5484 $\pm$ 0.1323	1.1636 $\pm$ 0.1147
Heart	0.0580 $\pm$ 0.0032	0.8442 $\pm$ 0.0660	0.6714 $\pm$ 0.0510
Lung	0.0713 $\pm$ 0.0069	1.2852 $\pm$ 0.1297	1.0446 $\pm$ 0.1054
Spleen	0.0660 $\pm$ 0.0040	1.1350 $\pm$ 0.0702	0.9018 $\pm$ 0.0476
Bone	0.0810 $\pm$ 0.0057	1.3300 $\pm$ 0.1053	1.0512 $\pm$ 0.0837
Proventriculus	0.0597 $\pm$ 0.0024	1.1974 $\pm$ 0.1031	0.9302 $\pm$ 0.0782
Gizzard	0.0667 $\pm$ 0.0047	1.2520 $\pm$ 0.0933	0.9876 $\pm$ 0.0867
Intestine	0.0693 $\pm$ 0.0058	1.3560 $\pm$ 0.0548	1.1030 $\pm$ 0.0466
Feather	0.2940 $\pm$ 0.0095	2.6994 $\pm$ 0.2466	2.1974 $\pm$ 0.1935
Claw	0.3250 $\pm$ 0.0174	3.2980 $\pm$ 0.4251	2.5246 $\pm$ 0.3400
Skin	0.1467 $\pm$ 0.0087	2.1610 $\pm$ 0.1108	1.7474 $\pm$ 0.0973
Brain	0.0217 $\pm$ 0.0030	0.3274 $\pm$ 0.0346	0.2410 $\pm$ 0.0256
Whole blood	0.0270 $\pm$ 0.0036	0.1024 $\pm$ 0.0176	0.0824 $\pm$ 0.0128
Plasma	0.0117 $\pm$ 0.0020	0.0510 $\pm$ 0.0096	0.0416 $\pm$ 0.0074
Blood cell	0.0373 $\pm$ 0.0042	0.1494 $\pm$ 0.0276	0.1234 $\pm$ 0.0205
Testis	0.0363 $\pm$ 0.0026	0.3938 $\pm$ 0.0904	0.3146 $\pm$ 0.0426
Faeces	0.1793 $\pm$ 0.0043	1.9500 $\pm$ 0.0868	1.5230 $\pm$ 0.0240
Meat	0.0480 $\pm$ 0.0110	0.8180 $\pm$ 0.2370	0.6470 $\pm$ 0.1860

Table . 9. Mean $\pm$ SE of concentration of arsenic in different body parts, organs, blood and faeces of desi cock, aged more than 22 weeks (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0603 $\pm$ 0.0045	0.7466 $\pm$ 0.0445	0.6492 $\pm$ 0.0181
Breast muscle	0.0273 $\pm$ 0.0020	0.3400 $\pm$ 0.0235	0.3190 $\pm$ 0.0089
Fat	0.0150 $\pm$ 0.0017	0.1340 $\pm$ 0.0065	0.1256 $\pm$ 0.0030
Liver	0.0940 $\pm$ 0.0026	1.8718 $\pm$ 0.1661	1.4890 $\pm$ 0.1186
Kidney	0.0820 $\pm$ 0.0044	1.7662 $\pm$ 0.1595	1.3560 $\pm$ 0.0843
Heart	0.0640 $\pm$ 0.0044	1.0004 $\pm$ 0.1050	0.7990 $\pm$ 0.0306
Lung	0.0813 $\pm$ 0.0071	1.6654 $\pm$ 0.0587	1.3688 $\pm$ 0.0226
Spleen	0.0707 $\pm$ 0.0030	1.2486 $\pm$ 0.0818	1.0076 $\pm$ 0.0321
Bone	0.0893 $\pm$ 0.0026	1.6146 $\pm$ 0.1451	1.1400 $\pm$ 0.0831
Proventriculus	0.0647 $\pm$ 0.0035	1.3228 $\pm$ 0.1206	1.0108 $\pm$ 0.0706
Gizzard	0.0720 $\pm$ 0.0040	1.3816 $\pm$ 0.1233	1.0626 $\pm$ 0.0870
Intestine	0.079 $\pm$ 0.0069	1.4798 $\pm$ 0.0719	1.2758 $\pm$ 0.0512
Feather	0.3153 $\pm$ 0.0096	2.7770 $\pm$ 0.2648	2.4332 $\pm$ 0.1824
Claw	0.3427 $\pm$ 0.0170	3.5874 $\pm$ 0.3981	3.2326 $\pm$ 0.2726
Skin	0.1563 $\pm$ 0.0084	2.3162 $\pm$ 0.0973	1.9016 $\pm$ 0.0907
Brain	0.0240 $\pm$ 0.0044	0.3332 $\pm$ 0.0403	0.2906 $\pm$ 0.0156
Whole blood	0.0293 $\pm$ 0.0026	0.1088 $\pm$ 0.0172	0.0964 $\pm$ 0.0155
Plasma	0.0137 $\pm$ 0.0015	0.0556 $\pm$ 0.0090	0.0458 $\pm$ 0.0069
Blood cell	0.0393 $\pm$ 0.0052	0.1604 $\pm$ 0.0261	0.1482 $\pm$ 0.0225
Testis	0.0407 $\pm$ 0.0020	0.4944 $\pm$ 0.1145	0.3879 $\pm$ 0.0614
Faeces	0.1697 $\pm$ 0.0035	1.8996 $\pm$ 0.0767	1.4914 $\pm$ 0.0219
Meat	0.0550 $\pm$ 0.0120	0.9130 $\pm$ 0.2650	0.7410 $\pm$ 0.2030

Claw, Feather, Skin, Liver, Kidney, Lung, Bone, Intestine, Gizzard, Proventriculus, Spleen, Heart, Thigh, Reproductive organs, Breast, Fat, Blood cell, Whole blood and Plasma.

It was found that female reproductive organ deposited higher level of arsenic than the male reproductive organ i.e. testis.

As a whole hen contained lesser arsenic than their male counterpart. Reason might be due to excretion of arsenic through egg of laying hen indicating a portion of deposited arsenic could be mobilized from different organs (Donaldson and Braune, 1999).

In both sexes, arsenic deposition in all organs found to be increased with the advancement of the age. Like broiler, arsenic concentration in meat in all age groups of both sexes of desi birds were more than the permissible limit of 0.1 mg/Kg (Kreuzer and Logdeser, 1980) but lower than the maximum residual level of 1 mg/kg (MFPO – Amended in 1992). But for long term consumption of such meat might have a significant contribution of arsenic toxicity.

4.1.5.3. Concentration of arsenic in different body parts, organs, blood and excreta of Bengal goat :

The mean values of total arsenic concentration in different tissues and body parts of two age group of each sex, i.e. buck, wether and doe are shown in Table 10, Table 11, Table 12, Table 13, Table 14 and Table 15. The arsenic content in different organs in Bengal goat were in the following order to a maximum possible extent :

Hoof > Hair > Skin > Liver > Kidney > Lung > Bone > Intestine > Abomasum > Spleen > Heart > Thigh muscle > Reproductive organs (except wether) > Breast muscle > Fat > Blood cell > Whole blood > Plasma.

Biswas, *et al.* (2000) assessed the residual concentration of arsenic in Bengal goat after inducing chronic inorganic arsenic toxicity for 3 weeks. The largest residual concentration of arsenic was in the liver followed by the intestine, kidney, skin, hair, bone, heart, skeletal

Table . 10. Mean $\pm$ SE of concentration of Arsenic in different body parts, organs, blood and excreta of Buck, aged up to 2 years (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0347 $\pm$ 0.0041	0.3986 $\pm$ 0.0474	0.3758 $\pm$ 0.0422
Breast muscle	0.0247 $\pm$ 0.0023	0.2828 $\pm$ 0.0328	0.2713 $\pm$ 0.0296
Fat	0.0080 $\pm$ 0.0021	0.0802 $\pm$ 0.0029	0.0828 $\pm$ 0.0032
Liver	0.0653 $\pm$ 0.0059	0.9536 $\pm$ 0.0861	0.8895 $\pm$ 0.0737
Kidney	0.0603 $\pm$ 0.0050	0.9234 $\pm$ 0.0964	0.8630 $\pm$ 0.0818
Heart	0.0383 $\pm$ 0.0023	0.4956 $\pm$ 0.0353	0.4583 $\pm$ 0.0368
Lung	0.0547 $\pm$ 0.0064	0.7570 $\pm$ 0.0640	0.6940 $\pm$ 0.0560
Spleen	0.0567 $\pm$ 0.0037	0.6582 $\pm$ 0.0706	0.6315 $\pm$ 0.0585
Bone	0.0577 $\pm$ 0.0060	0.8202 $\pm$ 0.0830	0.7308 $\pm$ 0.0751
Abomasum	0.0510 $\pm$ 0.0042	0.7500 $\pm$ 0.0811	0.7145 $\pm$ 0.0790
Intestine	0.0570 $\pm$ 0.0049	0.8082 $\pm$ 0.0986	0.7763 $\pm$ 0.0958
Hair	0.2840 $\pm$ 0.0057	1.4326 $\pm$ 0.1835	1.4153 $\pm$ 0.1680
Hoof	0.3130 $\pm$ 0.0162	1.6906 $\pm$ 0.1173	1.5775 $\pm$ 0.0930
Skin	0.1347 $\pm$ 0.0105	1.4556 $\pm$ 0.0716	1.3875 $\pm$ 0.0649
Brain	0.0197 $\pm$ 0.0032	0.2406 $\pm$ 0.0327	0.2068 $\pm$ 0.0191
Whole blood	0.0200 $\pm$ 0.0030	0.0814 $\pm$ 0.0150	0.0660 $\pm$ 0.0107
Plasma	0.0073 $\pm$ 0.0009	0.0324 $\pm$ 0.0053	0.0318 $\pm$ 0.0051
Blood cell	0.0280 $\pm$ 0.0023	0.1030 $\pm$ 0.0173	0.0995 $\pm$ 0.0169
Testis	0.0297 $\pm$ 0.0023	0.2838 $\pm$ 0.0349	0.2603 $\pm$ 0.0360
Urine	0.0630 $\pm$ 0.0038	0.8670 $\pm$ 0.0509	0.8053 $\pm$ 0.0423
Faeces	0.1607 $\pm$ 0.0081	1.5156 $\pm$ 0.0138	1.4565 $\pm$ 0.0101
Meat	0.0360 $\pm$ 0.0078	0.5110 $\pm$ 0.1220	0.4783 $\pm$ 0.1126

Table . 11. Mean $\pm$ SE of concentration of Arsenic in different body parts, organs, blood and excreta of Buck, aged more than 2 years (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0497 $\pm$ 0.0015	0.5206 $\pm$ 0.0526	0.4420 $\pm$ 0.0416
Breast muscle	0.0333 $\pm$ 0.0012	0.3724 $\pm$ 0.0353	0.3083 $\pm$ 0.0243
Fat	0.0097 $\pm$ 0.0018	0.1110 $\pm$ 0.0025	0.0910 $\pm$ 0.0013
Liver	0.0830 $\pm$ 0.0046	1.3296 $\pm$ 0.1253	0.9985 $\pm$ 0.0998
Kidney	0.0743 $\pm$ 0.0043	1.2180 $\pm$ 0.1056	0.9233 $\pm$ 0.0819
Heart	0.0570 $\pm$ 0.0021	0.6412 $\pm$ 0.0439	0.5315 $\pm$ 0.0347
Lung	0.0693 $\pm$ 0.0052	0.9174 $\pm$ 0.0561	0.7523 $\pm$ 0.0443
Spleen	0.0637 $\pm$ 0.0038	0.8858 $\pm$ 0.0576	0.7198 $\pm$ 0.0495
Bone	0.0790 $\pm$ 0.0032	1.1400 $\pm$ 0.1196	0.9518 $\pm$ 0.0860
Abomasum	0.0577 $\pm$ 0.0038	0.9664 $\pm$ 0.0748	0.7968 $\pm$ 0.0639
Intestine	0.0667 $\pm$ 0.0034	1.0170 $\pm$ 0.0696	0.9325 $\pm$ 0.0833
Hair	0.2933 $\pm$ 0.0084	1.7946 $\pm$ 0.2233	1.5913 $\pm$ 0.1743
Hoof	0.3277 $\pm$ 0.0176	2.1936 $\pm$ 0.1631	1.7880 $\pm$ 0.1270
Skin	0.1460 $\pm$ 0.0130	1.6004 $\pm$ 0.1711	1.5425 $\pm$ 0.0523
Brain	0.0233 $\pm$ 0.0027	0.3200 $\pm$ 0.0301	0.2403 $\pm$ 0.0148
Whole blood	0.0250 $\pm$ 0.0032	0.0892 $\pm$ 0.0135	0.0768 $\pm$ 0.0121
Plasma	0.0107 $\pm$ 0.0018	0.0448 $\pm$ 0.0073	0.0393 $\pm$ 0.0055
Blood cell	0.0360 $\pm$ 0.0038	0.1338 $\pm$ 0.0187	0.1258 $\pm$ 0.0179
Testis	0.0350 $\pm$ 0.0038	0.4112 $\pm$ 0.0628	0.3250 $\pm$ 0.0465
Urine	0.0550 $\pm$ 0.0038	0.8444 $\pm$ 0.0658	0.7110 $\pm$ 0.0482
Faeces	0.1550 $\pm$ 0.0044	1.4960 $\pm$ 0.0202	1.4153 $\pm$ 0.0178
Meat	0.0471 $\pm$ 0.0101	0.6880 $\pm$ 0.1660	0.5780 $\pm$ 0.1220

Table . 12. Mean $\pm$ SE of concentration of Arsenic in different body parts, organs, blood and excreta of wether, aged upto 2 years (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0340 $\pm$ 0.0040	0.4000 $\pm$ 0.0493	0.3718 $\pm$ 0.0416
Breast muscle	0.0240 $\pm$ 0.0026	0.2806 $\pm$ 0.0338	0.2683 $\pm$ 0.0310
Fat	0.0077 $\pm$ 0.0015	0.0790 $\pm$ 0.0026	0.0755 $\pm$ 0.0028
Liver	0.0647 $\pm$ 0.0062	0.9498 $\pm$ 0.0879	0.8990 $\pm$ 0.0757
Kidney	0.0597 $\pm$ 0.0050	0.9246 $\pm$ 0.1059	0.8558 $\pm$ 0.0821
Heart	0.0380 $\pm$ 0.0023	0.4916 $\pm$ 0.0391	0.4650 $\pm$ 0.0417
Lung	0.2490 $\pm$ 0.2005	0.7500 $\pm$ 0.0645	0.6970 $\pm$ 0.0561
Spleen	0.0560 $\pm$ 0.0036	0.6738 $\pm$ 0.0721	0.6273 $\pm$ 0.0562
Bone	0.0560 $\pm$ 0.0031	0.7482 $\pm$ 0.0676	0.7365 $\pm$ 0.0765
Abomasum	0.0570 $\pm$ 0.0060	0.7476 $\pm$ 0.0823	0.7090 $\pm$ 0.0756
Intestine	0.0497 $\pm$ 0.0035	0.8068 $\pm$ 0.0992	0.7725 $\pm$ 0.0910
Hair	0.2813 $\pm$ 0.0066	1.4340 $\pm$ 0.1876	1.4210 $\pm$ 0.1700
Hoof	0.3097 $\pm$ 0.0156	1.6878 $\pm$ 0.1184	1.5768 $\pm$ 0.0948
Skin	0.1310 $\pm$ 0.0136	1.5376 $\pm$ 0.1209	1.3673 $\pm$ 0.4015
Brain	0.0197 $\pm$ 0.0024	0.2344 $\pm$ 0.0321	0.2015 $\pm$ 0.0615
Whole blood	0.0180 $\pm$ 0.0010	0.0718 $\pm$ 0.0152	0.0615 $\pm$ 0.0085
Plasma	0.0067 $\pm$ 0.0007	0.0318 $\pm$ 0.0050	0.0305 $\pm$ 0.0041
Blood cell	0.0233 $\pm$ 0.0043	0.1018 $\pm$ 0.0177	0.0900 $\pm$ 0.0133
Urine	0.0623 $\pm$ 0.0047	0.8652 $\pm$ 0.0515	0.8063 $\pm$ 0.0394
Faeces	0.1583 $\pm$ 0.0065	1.5136 $\pm$ 0.0150	1.5565 $\pm$ 0.0889
Meat	0.0356 $\pm$ 0.0079	0.5080 $\pm$ 0.1220	0.4760 $\pm$ 0.1140

Table . 13. Mean $\pm$ SE of concentration of Arsenic in different body parts, organs, blood and excreta of wether, aged more than 2 years (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0483 $\pm$ 0.0033	0.5176 $\pm$ 0.0552	0.4323 $\pm$ 0.0448
Breast muscle	0.0313 $\pm$ 0.0009	0.3746 $\pm$ 0.0341	0.3035 $\pm$ 0.0262
Fat	0.0090 $\pm$ 0.0021	0.1088 $\pm$ 0.0031	0.0860 $\pm$ 0.0037
Liver	0.0807 $\pm$ 0.0061	1.3194 $\pm$ 0.1210	0.9843 $\pm$ 0.0848
Kidney	0.0727 $\pm$ 0.0061	1.2116 $\pm$ 0.1077	0.9248 $\pm$ 0.0832
Heart	0.0563 $\pm$ 0.0032	0.6360 $\pm$ 0.0426	0.5223 $\pm$ 0.0401
Lung	0.0673 $\pm$ 0.0069	0.9052 $\pm$ 0.0544	0.7470 $\pm$ 0.0467
Spleen	0.0623 $\pm$ 0.0049	0.8802 $\pm$ 0.0626	0.7095 $\pm$ 0.0593
Bone	0.773 $\pm$ 0.0047	1.1294 $\pm$ 0.1209	0.9445 $\pm$ 0.0833
Abomasum	0.0557 $\pm$ 0.0041	0.9486 $\pm$ 0.0689	0.7928 $\pm$ 0.0683
Intestine	0.0690 $\pm$ 0.0023	1.0086 $\pm$ 0.0727	0.9358 $\pm$ 0.0917
Hair	0.2900 $\pm$ 0.0113	1.7784 $\pm$ 0.2230	1.5918 $\pm$ 0.1776
Hoof	0.3223 $\pm$ 0.0171	2.1836 $\pm$ 0.1669	1.7215 $\pm$ 0.1007
Skin	0.1440 $\pm$ 0.0138	1.5740 $\pm$ 0.1801	1.5345 $\pm$ 0.0681
Brain	0.0223 $\pm$ 0.0023	0.3152 $\pm$ 0.0297	0.2333 $\pm$ 0.0186
Whole blood	0.0240 $\pm$ 0.0031	0.0882 $\pm$ 0.0137	0.0730 $\pm$ 0.0110
Plasma	0.0100 $\pm$ 0.0025	0.0430 $\pm$ 0.0070	0.0378 $\pm$ 0.0051
Blood cell	0.0337 $\pm$ 0.0032	0.1280 $\pm$ 0.0186	0.1195 $\pm$ 0.0160
Urine	0.0537 $\pm$ 0.0048	0.8526 $\pm$ 0.0555	0.7413 $\pm$ 0.0402
Faeces	0.1500 $\pm$ 0.0059	1.4864 $\pm$ 0.0194	1.4353 $\pm$ 0.0150
Meat	0.0457 $\pm$ 0.0100	0.6834 $\pm$ 0.1649	0.5410 $\pm$ 0.1210

Table. 14. Mean $\pm$ SE of concentration of arsenic in different body parts, organs, blood and excreta of doe, aged upto 2 years (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0317 $\pm$ 0.0035	0.3954 $\pm$ 0.0455	0.3753 $\pm$ 0.0428
Breast muscle	0.0213 $\pm$ 0.0015	0.2812 $\pm$ 0.0311	0.2620 $\pm$ 0.0284
Fat	0.0053 $\pm$ 0.0012	0.0786 $\pm$ 0.0019	0.0733 $\pm$ 0.0016
Liver	0.0620 $\pm$ 0.0062	0.9466 $\pm$ 0.0906	0.8805 $\pm$ 0.0761
Kidney	0.0540 $\pm$ 0.0029	0.9068 $\pm$ 0.0926	0.8483 $\pm$ 0.0819
Heart	0.0353 $\pm$ 0.0026	0.4890 $\pm$ 0.0364	0.4515 $\pm$ 0.0342
Lung	0.0510 $\pm$ 0.0067	0.7506 $\pm$ 0.0635	0.6860 $\pm$ 0.0536
Spleen	0.0537 $\pm$ 0.0037	0.6632 $\pm$ 0.0641	0.6160 $\pm$ 0.0582
Bone	0.0547 $\pm$ 0.0050	0.8124 $\pm$ 0.0820	0.7263 $\pm$ 0.0783
Abomasum	0.0490 $\pm$ 0.0040	0.7516 $\pm$ 0.0859	0.7038 $\pm$ 0.0796
Intestine	0.0517 $\pm$ 0.0047	0.8002 $\pm$ 0.0919	0.7680 $\pm$ 0.0920
Hair	0.2717 $\pm$ 0.0061	1.4338 $\pm$ 0.1843	1.4043 $\pm$ 0.1694
Hoof	0.3010 $\pm$ 0.0193	1.6780 $\pm$ 0.1157	1.5670 $\pm$ 0.0949
Skin	0.1203 $\pm$ 0.0098	1.4570 $\pm$ 0.0685	1.3723 $\pm$ 0.0613
Brain	0.0183 $\pm$ 0.0043	0.2394 $\pm$ 0.0303	0.1973 $\pm$ 0.0191
Whole blood	0.0193 $\pm$ 0.0009	0.0712 $\pm$ 0.0119	0.0608 $\pm$ 0.0096
Plasma	0.0067 $\pm$ 0.0003	0.0324 $\pm$ 0.0055	0.0295 $\pm$ 0.0046
Blood cell	0.0257 $\pm$ 0.0034	0.1004 $\pm$ 0.0180	0.0860 $\pm$ 0.0119
Ovary	0.0360 $\pm$ 0.0040	0.3294 $\pm$ 0.0449	0.2980 $\pm$ 0.0397
Urine	0.0617 $\pm$ 0.0054	0.8750 $\pm$ 0.0493	0.8230 $\pm$ 0.0450
Faeces	0.1607 $\pm$ 0.0038	1.4966 $\pm$ 0.0116	1.4633 $\pm$ 0.0100
Meat	0.0324 $\pm$ 0.0076	0.5070 $\pm$ 0.1180	0.4697 $\pm$ 0.1120

Table. 15. Mean $\pm$ SE of concentration of arsenic in different body parts, organs, blood and excreta of doe, aged more than 2 years (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Thigh muscle	0.0373 $\pm$ 0.0024	0.4476 $\pm$ 0.0549	0.4118 $\pm$ 0.0478
Breast muscle	0.0263 $\pm$ 0.0015	0.3222 $\pm$ 0.0374	0.2908 $\pm$ 0.0321
Fat	0.0063 $\pm$ 0.0015	0.0924 $\pm$ 0.0021	0.0820 $\pm$ 0.0023
Liver	0.0773 $\pm$ 0.0060	1.1244 $\pm$ 0.0980	0.9260 $\pm$ 0.0818
Kidney	0.0623 $\pm$ 0.0058	1.0724 $\pm$ 0.1023	0.8788 $\pm$ 0.0853
Heart	0.0460 $\pm$ 0.0035	0.5388 $\pm$ 0.0425	0.4830 $\pm$ 0.0402
Lung	0.0603 $\pm$ 0.0064	0.7686 $\pm$ 0.0425	0.6930 $\pm$ 0.0431
Spleen	0.0563 $\pm$ 0.0055	0.7444 $\pm$ 0.0573	0.6663 $\pm$ 0.0526
Bone	0.0573 $\pm$ 0.0064	0.9848 $\pm$ 0.1050	0.8935 $\pm$ 0.0833
Abomasum	0.0483 $\pm$ 0.0050	0.8558 $\pm$ 0.0796	0.7663 $\pm$ 0.0751
Intestine	0.0523 $\pm$ 0.0055	0.9222 $\pm$ 0.0680	0.9110 $\pm$ 0.0958
Hair	0.2840 $\pm$ 0.0174	1.5618 $\pm$ 0.2022	1.5038 $\pm$ 0.1821
Hoof	0.3210 $\pm$ 0.0172	1.8122 $\pm$ 0.1478	1.6935 $\pm$ 0.1532
Skin	0.1337 $\pm$ 0.0105	1.5900 $\pm$ 0.0647	1.4438 $\pm$ 0.0582
Brain	0.0213 $\pm$ 0.0043	0.3030 $\pm$ 0.0243	0.2070 $\pm$ 0.0199
Whole blood	0.0203 $\pm$ 0.0007	0.0804 $\pm$ 0.0120	0.0670 $\pm$ 0.0120
Plasma	0.0080 $\pm$ 0.0006	0.0370 $\pm$ 0.0062	0.0330 $\pm$ 0.0051
Blood cell	0.0270 $\pm$ 0.0031	0.1182 $\pm$ 0.0194	0.0978 $\pm$ 0.0154
ovary	0.0403 $\pm$ 0.0033	0.3954 $\pm$ 0.0618	0.3678 $\pm$ 0.0582
Urine	0.0583 $\pm$ 0.0050	0.8272 $\pm$ 0.0517	0.7433 $\pm$ 0.0439
Faeces	0.3123 $\pm$ 0.1588	1.5776 $\pm$ 0.1012	1.4435 $\pm$ 0.0105
Meat	0.0393 $\pm$ 0.0093	0.5870 $\pm$ 0.1430	0.5080 $\pm$ 0.1150

muscles and lowest in the brain tissue. Results of Biswas *et al.* (2000) and of the present study indicated that with the increasing time of chronic exposure, increases the deposition of arsenic in keratinized tissue such as hoof, hair and skin. Such results were also noted by Vaheter and Marafante (1983) and Robb *et al.* (2002).

Data revealed that birds except broiler tended to deposit the higher level of arsenic in the system than the Bengal goat. Present study can be explained by the observation of Doyle and Spaulding (1978) who showed that arsenic level in some edible tissues such as liver, kidney and muscle of cattle, sheep, swine and chickens. Concentration of arsenic in liver and kidney appeared very low for all species except chickens.

4.1.5.4. Concentration of arsenic in different tissues of fish :

Different fish species like Common carp, Rohu and Catla of both juvenile and adult stages were collected to estimate the arsenic concentration in dorsal muscle, abdominal muscle, liver, kidney, heart, gill, spleen, eye, scale, fin, whole blood and fish flesh. Data of different species and different age group were presented in Table 16, Table 17, Table 18, Table 19, Table 20 and Table 21.

In all the cases arsenic concentration in all tissues and body parts were increased with the advancement of age but this increment did not reflect the order of the deposition. The deposition of arsenic was highest in fin followed by scale, liver, eye, kidney, spleen, gill, heart, abdominal muscle, dorsal muscle and least in whole blood.

Present findings corroborated the observation of Saiki and May (1988) who found mean arsenic concentration ranged from 0.18 to 0.44 mg/kg for bluegill sunfish and from 0.23 to 0.39 mg/kg for Common carp and also to the findings of Takatsu and Uchiumi (1998) who analyzed fish from the naturally acidified volcanic lake where

Table. 16. Mean $\pm$ SE of concentration of arsenic in different body parts, organs and blood of juvenile common carp, aged upto 6 months (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Dorsal muscle	0.0150 $\pm$ 0.0015	0.3418 $\pm$ 0.0691	0.3018 $\pm$ 0.0568
Abdominal muscle	0.0220 $\pm$ 0.0012	0.4374 $\pm$ 0.0639	0.4054 $\pm$ 0.0493
Liver	0.0307 $\pm$ 0.0035	0.6216 $\pm$ 0.0615	0.5954 $\pm$ 0.0522
Kidney	0.0273 $\pm$ 0.0023	0.5686 $\pm$ 0.0485	0.5390 $\pm$ 0.0350
Heart	0.0227 $\pm$ 0.0026	0.4740 $\pm$ 0.0724	0.4304 $\pm$ 0.0506
Gill	0.0248 $\pm$ 0.0023	0.5348 $\pm$ 0.0659	0.4838 $\pm$ 0.0354
Spleen	0.0257 $\pm$ 0.0038	0.5676 $\pm$ 0.0634	0.5148 $\pm$ 0.0385
Eye	0.0270 $\pm$ 0.0026	0.6018 $\pm$ 0.0575	0.5902 $\pm$ 0.0464
Scale	0.0333 $\pm$ 0.0028	0.7652 $\pm$ 0.1144	0.7274 $\pm$ 0.0742
Fin	0.0430 $\pm$ 0.0049	0.8730 $\pm$ 0.1208	0.6552 $\pm$ 0.1385
Whole blood	0.0097 $\pm$ 0.0012	0.0580 $\pm$ 0.0081	0.0496 $\pm$ 0.0047
Fish flesh	0.0190 $\pm$ 0.0040	0.3890 $\pm$ 0.0470	0.3540 $\pm$ 0.0520

Table. 17. Mean $\pm$ SE of concentration of arsenic in different body parts, organs and blood of adult common carp, aged more than 6 months (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Dorsal muscle	0.0187 $\pm$ 0.0027	0.4010 $\pm$ 0.0903	0.3328 $\pm$ 0.0562
Abdominal muscle	0.0243 $\pm$ 0.0035	0.5544 $\pm$ 0.0586	0.5076 $\pm$ 0.0472
Liver	0.0367 $\pm$ 0.0032	0.8040 $\pm$ 0.0767	0.7484 $\pm$ 0.0605
Kidney	0.0323 $\pm$ 0.0029	0.7272 $\pm$ 0.0646	0.7152 $\pm$ 0.0583
Heart	0.0253 $\pm$ 0.0023	0.5812 $\pm$ 0.0702	0.5676 $\pm$ 0.0520
Gill	0.0287 $\pm$ 0.0026	0.6852 $\pm$ 0.0342	0.6680 $\pm$ 0.0283
Spleen	0.0317 $\pm$ 0.0023	0.7028 $\pm$ 0.0470	0.6952 $\pm$ 0.0361
Eye	0.0330 $\pm$ 0.0026	0.7722 $\pm$ 0.0707	0.7212 $\pm$ 0.0637
Scale	0.0427 $\pm$ 0.0035	0.9704 $\pm$ 0.1010	0.9746 $\pm$ 0.0828
Fin	0.0507 $\pm$ 0.0032	1.1020 $\pm$ 0.1206	1.1176 $\pm$ 0.1079
Whole blood	0.0113 $\pm$ 0.0015	0.0870 $\pm$ 0.0075	0.0704 $\pm$ 0.0081
Fish flesh	0.0220 $\pm$ 0.0030	0.4770 $\pm$ 0.0770	0.4210 $\pm$ 0.0880

Table. 18. Mean $\pm$ SE of concentration of arsenic in different body parts, organs and blood of juvenile rohu, aged upto 6months (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Dorsal muscle	0.0137 $\pm$ 0.0019	0.2824 $\pm$ 0.0504	0.2310 $\pm$ 0.0332
Abdominal muscle	0.0203 $\pm$ 0.0007	0.3978 $\pm$ 0.0486	0.3400 $\pm$ 0.0276
Liver	0.0260 $\pm$ 0.0029	0.5790 $\pm$ 0.0477	0.5372 $\pm$ 0.0335
Kidney	0.0237 $\pm$ 0.0015	0.5500 $\pm$ 0.0452	0.5046 $\pm$ 0.0297
Heart	0.0219 $\pm$ 0.0020	0.4196 $\pm$ 0.0457	0.3712 $\pm$ 0.0256
Gill	0.0223 $\pm$ 0.0020	0.4874 $\pm$ 0.0419	0.4310 $\pm$ 0.0181
Spleen	0.0227 $\pm$ 0.0027	0.5198 $\pm$ 0.0444	0.4548 $\pm$ 0.0182
Eye	0.0247 $\pm$ 0.0035	0.5664 $\pm$ 0.0433	0.5352 $\pm$ 0.0283
Scale	0.0343 $\pm$ 0.0038	0.7058 $\pm$ 0.0826	0.6628 $\pm$ 0.0636
Fin	0.0380 $\pm$ 0.0035	0.7986 $\pm$ 0.0975	0.7216 $\pm$ 0.0804
Whole blood	0.0073 $\pm$ 0.0012	0.0510 $\pm$ 0.0069	0.0434 $\pm$ 0.0048
Fish flesh	0.0170 $\pm$ 0.0030	0.3400 $\pm$ 0.0580	0.2850 $\pm$ 0.0540

Table. 19. Mean $\pm$ SE of concentration of arsenic in different body parts, organs and blood of adult rohu, aged more than 6 months (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Dorsal muscle	0.0157 $\pm$ 0.0023	0.3532 $\pm$ 0.0704	0.2816 $\pm$ 0.0433
Abdominal muscle	0.0217 $\pm$ 0.0015	0.5076 $\pm$ 0.0454	0.4414 $\pm$ 0.0257
Liver	0.0327 $\pm$ 0.0035	0.7370 $\pm$ 0.0558	0.6460 $\pm$ 0.0421
Kidney	0.0290 $\pm$ 0.0029	0.7074 $\pm$ 0.0518	0.6192 $\pm$ 0.0409
Heart	0.0237 $\pm$ 0.0024	0.5656 $\pm$ 0.0594	0.4714 $\pm$ 0.0199
Gill	0.0263 $\pm$ 0.0023	0.6610 $\pm$ 0.0288	0.4834 $\pm$ 0.0172
Spleen	0.0280 $\pm$ 0.0021	0.7070 $\pm$ 0.0431	0.4984 $\pm$ 0.0120
Eye	0.0283 $\pm$ 0.0023	0.7136 $\pm$ 0.0546	0.6274 $\pm$ 0.0378
Scale	0.0393 $\pm$ 0.0026	0.9280 $\pm$ 0.0762	0.9036 $\pm$ 0.0754
Fin	0.0467 $\pm$ 0.0032	1.0336 $\pm$ 0.0996	0.9396 $\pm$ 0.0883
Whole blood	0.0093 $\pm$ 0.0009	0.0760 $\pm$ 0.0057	0.640 $\pm$ 0.0069
Fish flesh	0.0190 $\pm$ 0.0030	0.4310 $\pm$ 0.0780	0.3620 $\pm$ 0.0800

Table. 20. Mean $\pm$ SE of concentration of arsenic in different body parts, organs and blood of juvenile catla, aged upto 6 months (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Dorsal muscle	0.0100 $\pm$ 0.0021	0.2490 $\pm$ 0.0455	0.2134 $\pm$ 0.0284
Abdominal muscle	0.0167 $\pm$ 0.0024	0.3776 $\pm$ 0.0443	0.3160 $\pm$ 0.0232
Liver	0.0237 $\pm$ 0.0041	0.5392 $\pm$ 0.0305	0.4992 $\pm$ 0.0277
Kidney	0.0213 $\pm$ 0.0035	0.5172 $\pm$ 0.0320	0.4572 $\pm$ 0.0247
Heart	0.0183 $\pm$ 0.0022	0.4056 $\pm$ 0.0429	0.3540 $\pm$ 0.0208
Gill	0.0190 $\pm$ 0.0026	0.4742 $\pm$ 0.0426	0.4002 $\pm$ 0.0108
Spleen	0.0210 $\pm$ 0.0021	0.5022 $\pm$ 0.0446	0.4218 $\pm$ 0.0162
Eye	0.0223 $\pm$ 0.0020	0.5256 $\pm$ 0.0427	0.4800 $\pm$ 0.0274
Scale	0.0337 $\pm$ 0.0022	0.6826 $\pm$ 0.0806	0.6128 $\pm$ 0.0542
Fin	0.0390 $\pm$ 0.0025	0.7680 $\pm$ 0.0954	0.6634 $\pm$ 0.0584
Whole blood	0.0073 $\pm$ 0.0012	0.0488 $\pm$ 0.0059	0.0404 $\pm$ 0.0037
Fish flesh	0.0140 $\pm$ 0.0040	0.3140 $\pm$ 0.0650	0.2640 $\pm$ 0.0520

Table. 21. Mean $\pm$ SE of concentration of arsenic in different body parts, organs and blood of adult catla, aged more than 6 months (mg/kg or mg/l).

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Dorsal muscle	0.0140 $\pm$ 0.0023	0.3366 $\pm$ 0.0654	0.2598 $\pm$ 0.0375
Abdominal muscle	0.0203 $\pm$ 0.0018	0.4772 $\pm$ 0.0437	0.4092 $\pm$ 0.0213
Liver	0.0307 $\pm$ 0.0041	0.7058 $\pm$ 0.0538	0.5978 $\pm$ 0.0332
Kidney	0.0273 $\pm$ 0.0032	0.6756 $\pm$ 0.0457	0.5634 $\pm$ 0.0321
Heart	0.0210 $\pm$ 0.0026	0.5314 $\pm$ 0.0588	0.4278 $\pm$ 0.0207
Gill	0.0240 $\pm$ 0.0023	0.6460 $\pm$ 0.0364	0.4490 $\pm$ 0.0143
Spleen	0.0257 $\pm$ 0.0032	0.6568 $\pm$ 0.0550	0.4668 $\pm$ 0.0131
Eye	0.0270 $\pm$ 0.0023	0.8928 $\pm$ 0.0674	0.5718 $\pm$ 0.0327
Scale	0.0387 $\pm$ 0.0023	0.9882 $\pm$ 0.0904	0.8448 $\pm$ 0.0758
Fin	0.0457 $\pm$ 0.0030	0.6302 $\pm$ 0.0310	0.8830 $\pm$ 0.0687
Whole blood	0.0087 $\pm$ 0.0009	0.0718 $\pm$ 0.0056	0.0568 $\pm$ 0.0066
Fish flesh	0.0170 $\pm$ 0.0030	0.4070 $\pm$ 0.0700	0.3350 $\pm$ 0.0750

mean arsenic levels were 0.28 and 0.27 mg/kg (wet weight) for gills and bones respectively and 6.1 mg/kg for eye tissues.

Svobodova *et al.* (2002) assessed the content of arsenic in market ready rainbow trout from 8 trout farms in the Czech Republic. In case of two trout farms the arsenic content recorded as exceeded the permissible limit of 1 mg/kg valid for freshwater fish. Though the mean arsenic content of present finding did not exceed the maximum permissible limit of 1 mg/kg but for long term consumption of such contaminated fish might have impact over the health of the consumers.

4.1.6. Arsenic concentration in different animal products :

Residual concentration of arsenic in different body parts of animals is very important for causing chronic arsenic poisoning. Such residues in animal body can get access to animal products which can also play the same role to consumers of such products like egg and milk in terms of developing arsenic toxicity.

4.1.6.1. Arsenic concentration in egg and its different components :

Table 22 represented the arsenic contents in different components of hen egg. All the components of egg from affected G.P. contained higher value than that of control G.P. Among the different components of egg in each G.P. yolk showed highest concentration of arsenic and shell showed least. The ratio of arsenic content in whole egg, yolk and albumin was found to be about 2:3:1. Like present findings Holcman and Stibilz (1997) found the ratio between arsenic in the yolk and in the egg whites and it was nearly in the ratio 3:1. Statistical analysis (Table 23) revealed that concentration of arsenic of whole egg of affected G.P. significantly differed ($P < 0.01$) from the whole egg arsenic concentration of the unaffected G.P. There was no

Table. 22. Mean $\pm$ SE of concentration of Arsenic in different components of hen egg (mg/kg)

ITEMS	GOLGRAM (CONTROL)	KOLSUR	HADIPUR- JHIKRA-I
Whole egg	0.0247 $\pm$ 0.0020	0.2752 $\pm$ 0.0241	0.2450 $\pm$ 0.0239
Yolk	0.0360 $\pm$ 0.0035	0.5551 $\pm$ 0.0477	0.4665 $\pm$ 0.0407
Albumin	0.0110 $\pm$ 0.0012	0.1613 $\pm$ 0.0141	0.1471 $\pm$ 0.0138
shell	0.0083 $\pm$ 0.0003	0.0651 $\pm$ 0.0055	0.0601 $\pm$ 0.0057

Fig. 4: Showing arsenic residue in different components of egg

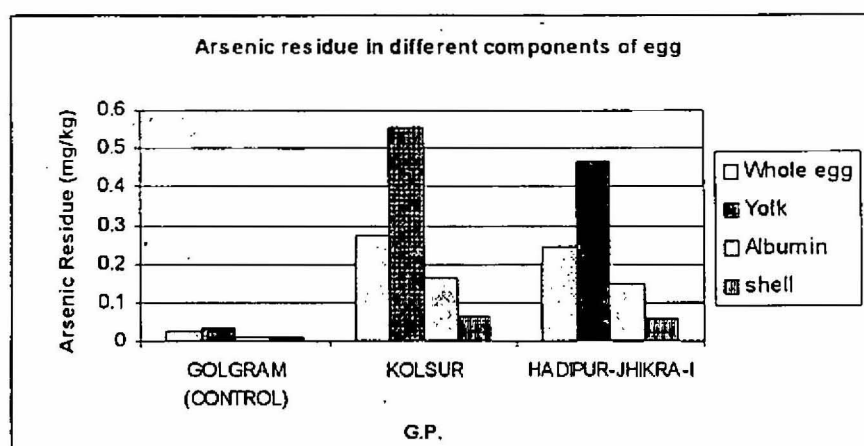


Table 23. Mean $\pm$ SE with Test of significance of variation of arsenic residue in whole egg and milk in different G.P.

	Golgram (control)	Kolsur	Hadipur Jhikra-I	d.f. with t- value					
				d.f.	t ₁	d.f.	t ₂	d.f.	t ₃
Whole egg	0.0247 $\pm$ 0.0020	0.2752 $\pm$ 0.0241	0.2450 $\pm$ 0.0239	21	3.9491**	21	3.5040**	38	0.8907 ^{NS}
Cow-milk	0.0017 $\pm$ 0.0003	0.0082 $\pm$ 0.0007	0.0063 $\pm$ 0.0003	31	2.9461**	31	3.9059**	58	2.4593*
Goat milk	0.0013 $\pm$ 0.0003	0.0063 $\pm$ 0.0004	0.0056 $\pm$ 0.0003	31	4.3901**	31	3.9611**	58	1.2724 ^{NS}

t₁ = Golgram Vs. Kolsur, t₂ = Golgram Vs. Hadipur Jhikra-I,

t₃ = Kolsur Vs. Hadipur Jhikra-I

* = P < 0.05 ** = P < 0.01 NS = Non-significant

significant difference of whole egg arsenic level between two affected G.P.

4.1.6.2. Concentration of arsenic in cow and goat milk

Table 23 stated the concentration of arsenic in cow and goat milk. Arsenic concentration of cow milk among three G.Ps. namely Golgram, Kolsur and Hadipur-Jhikra-I differed significantly ($P < 0.05$ and $P < 0.01$) whereas in case of goat milk there was no statistical difference of arsenic concentration between two affected G.P. but each of them varied significantly ($P < 0.01$) from the unaffected G.P. From the Table 24 it was cleared that only in Kolsur, the arsenic concentration of cow milk and goat milk showed significant difference ($P < 0.05$) but in other two G.Ps there were no significant difference.

In comparison to different tissues and other animal products milk showed least arsenic concentration due to blood mammary barrier which does not allow to pass the arsenic readily (de Navarro, 1976), suggesting excretion of arsenic through milk is very less and the value obtained in the present study might seem to be safe. Present findings resembled the observation of Rosas *et al.* (1999) who found arsenic concentration in milk ranged from less than 0.9 to 27.4 ng/g.

Arsenic is not only excreted through milk but also through urine and faeces. In case of animals urine arsenic and in case of poultry faeces arsenic concentration are considered as indicator of arsenic exposure. Though the milk concentration of arsenic was low in affected areas but arsenic content in urine and faeces were high in exposed animals and birds. Present study also revealed that the excreta of younger age group contained higher concentration of arsenic than that of adult of all species of animals. This finding is correlated with the observation of Das *et al.* (1995) who reported that excretion of arsenic was higher in children.

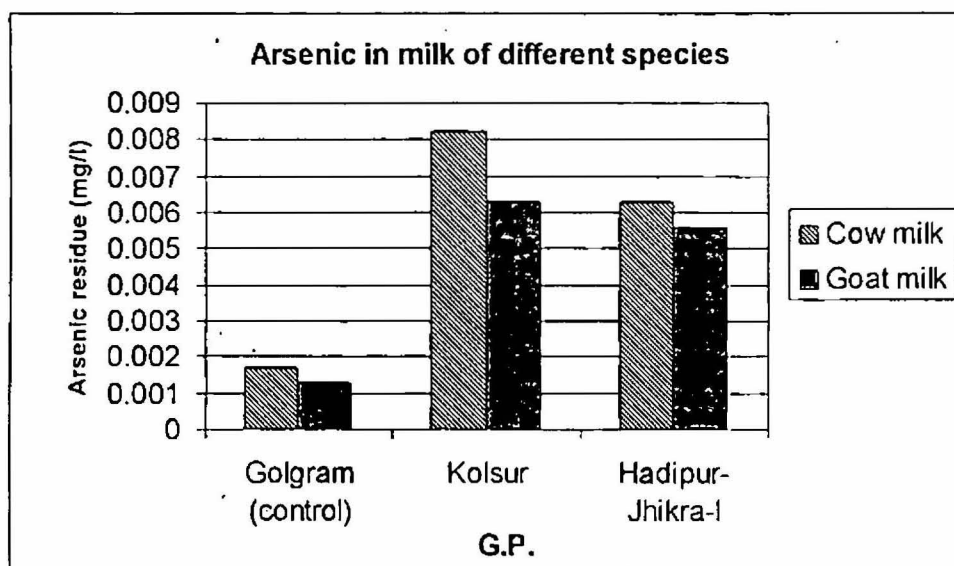
Table 24. Mean $\pm$ SE with Test of significance of variation of arsenic residue in milk in different G.P.

	Cow milk	Goat milk	d.f.	t-value
Golgram (control)	0.0017 $\pm$ 0.0003	0.0013 $\pm$ 0.0003	4	0.7071 ^{NS}
Kolsur	0.0082 $\pm$ 0.0007	0.0063 $\pm$ 0.0004	58	2.5538*
Hadipur- Jhikra-I	0.0063 $\pm$ 0.0003	0.0063 $\pm$ 0.0003	58	1.3340 ^{NS}

* = $P < 0.05$

NS = Non-significant

Fig. 5: Showing variation of arsenic residue in milk of different species



4.2. Variation of arsenic residue with rearing system (in bird)

When comparing the arsenic residue between broiler birds which reared in intensive system and provided ground water for drinking purpose and desi birds reared in free range system and provided both ground and surface water for drinking purpose, it was found that desi birds contained a little higher amount of arsenic than that of the broilers. Though the desi birds were sacrificed in much advanced age compared to broiler bird, the arsenic residue in the organs were little high might be due to lower level of arsenic exposure through surface water.

4.3. Variation of arsenic residue with age :

To mark the variation of arsenic with age only liver was considered because liver is the first internal targeted organ in the body whereas in case of fish abdominal muscle was taken as the part of experiment.

4.3.1. Variation of arsenic residue with age in broiler and desi birds :

Data on variation of arsenic residue with age in broiler and desi birds were presented in Table 25 and Table 26. Data revealed the significant differences ($P < 0.01$) of arsenic concentration in liver between two age groups of broiler i.e., 25-30 days and 40-50 days in each G.P. and the deposition tended to be higher with the advancement of age whereas in case of hen and cock there was no significant difference of arsenic concentration in liver of 22 weeks in any G.P. though there was higher value in advanced age group.

4.3.2. Variation of arsenic residue with age in Bengal goat :

Though the concentration of arsenic in liver (Table 27) was increased with the advancement of age of buck, wether and doe but no

Table 25. Mean $\pm$ SE with Test of significance of variation of arsenic residue in liver of broiler bird at different age

	25-30 days	40-50 days	d.f.	t-value
Golgram Control	0.0470 ± 0.0021	0.0777 ± 0.0059	4	4.8829**
Kolsur	0.9246 ± 0.0620	1.5976 ± 0.1342	8	4.5511**
Hadipur-Jhikra-I	0.7624 ± 0.0487	1.2588 ± 0.1046	8	4.3019**

** = $P < 0.01$

NS = Non-significant

Fig. 6: Showing mean $\pm$ SE with Test of significance of variation of arsenic residues in liver of broiler bird at different age.

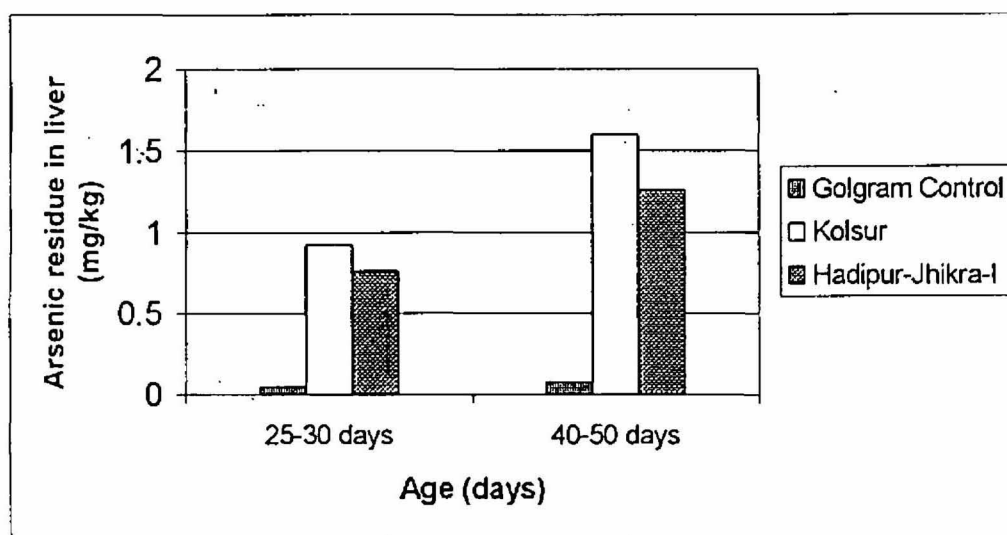


Table 26. Mean $\pm$ SE with Test of significance of variation of arsenic residue in liver of desi bird at different age.

	Hen				Cock			
	Upto 22 weeks	More than 22 weeks	d.f.	t-value	Upto 22 weeks	More than 22 weeks	d.f.	t-value
Golgram (control)	0.0840 ± 0.0046	0.0907 ± 0.0043	4	1.0526 ^{NS}	0.0803 ± 0.0050	0.0940 ± 0.0026	4	0.6565 ^{NS}
Kolsur	1.6776 ± 0.1561	1.7788 ± 0.1655	8	0.2338 ^{NS}	1.6868 ± 0.1622	1.8718 ± 0.1661	8	0.9749 ^{NS}
Hadipur-Jhikra-I	1.3196 ± 0.1214	1.3620 ± 0.1347	8	0.4448 ^{NS}	1.3256 ± 0.1185	1.4890 ± 0.1186	8	0.7969 ^{NS}

NS = Non-significant

Fig. 7: Showing arsenic residue in liver of desi bird with age

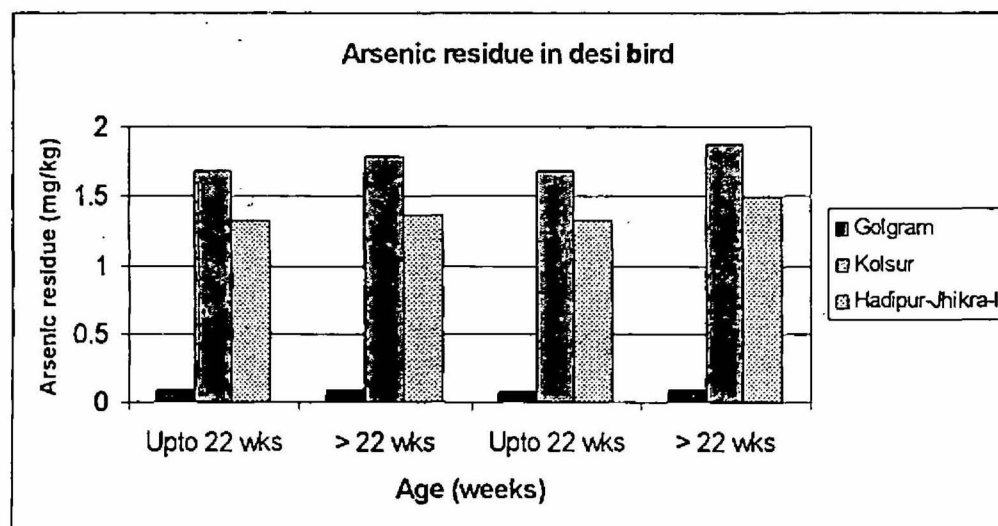


Table 27. Mean $\pm$ SE with Test of significance of variation of arsenic residues in liver of Bengal goat at different age

	Golgram (control)	Kolsur	Hadipur Jhikra-I
Buck			
Up to 2 yrs	0.0653 $\pm$ 0.0059	0.9536 $\pm$ 0.0861	0.8895 $\pm$ 0.0737
> 2 yrs	0.0830 $\pm$ 0.0046	1.3296 $\pm$ 0.1253	0.9985 $\pm$ 0.0998
d.f.	4	8	8
t-value	2.3515 ^{NS}	2.4737*	0.8790 ^{NS}
Wether			
Up to 2 yrs	0.0647 $\pm$ 0.0062	0.9448 $\pm$ 0.0879	0.8990 $\pm$ 0.0757
> 2 yrs	0.0807 $\pm$ 0.0061	1.3194 $\pm$ 0.1210	0.9843 $\pm$ 0.0848
d.f.	4	8	8
t-value	1.8407 ^{NS}	2.4712*	0.7500 ^{NS}
Doe			
Up to 2 yrs	0.0620 $\pm$ 0.0062	0.09466 $\pm$ 0.0906	0.8805 $\pm$ 0.0761
> 2 yrs	0.0773 $\pm$ 0.0060	1.1244 $\pm$ 0.0980	0.9260 $\pm$ 0.0818
d.f.	4	4	8
t-value	1.7692 ^{NS}	1.7692 ^{NS}	0.4073 ^{NS}

* = P < 0.05

NS = Non-significant

Fig. 8: Showing variation of arsenic residues in liver of Bengal goat at different age (B= Buck, W= Wether, D= Doe)

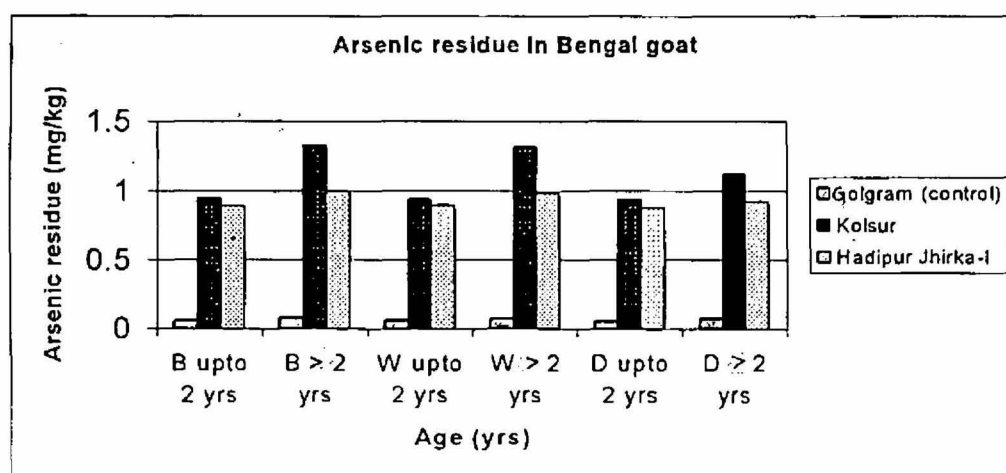


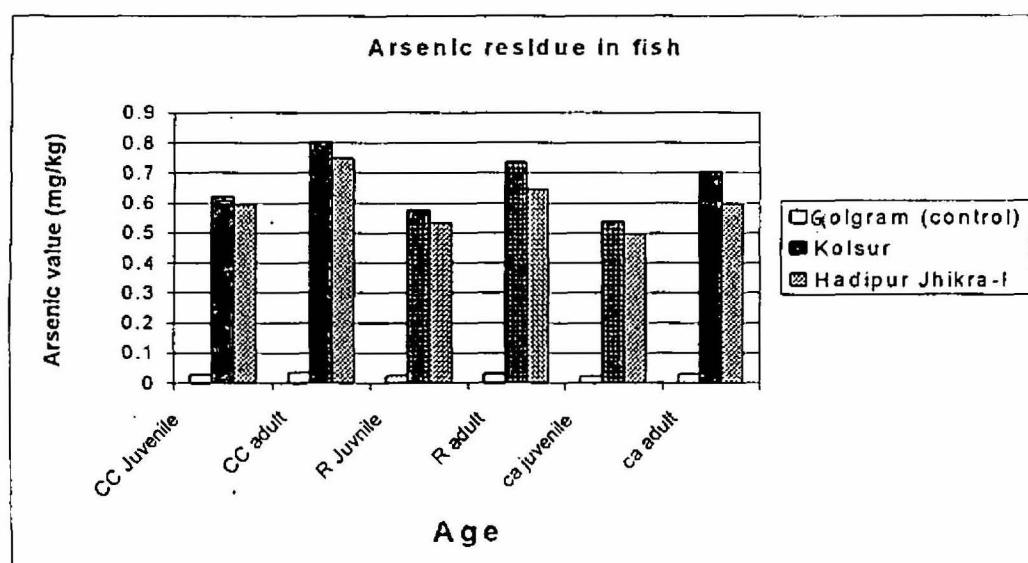
Table 28. Mean $\pm$ SE with Test of significance of variation of arsenic residues in abdominal muscle of fish at different age

	Golgram (control)	Kolsur	Hadipur Jhikra-I
Common carp			
Juvenile	0.0307 $\pm$ 0.0035	0.6216 $\pm$ 0.0615	0.5954 $\pm$ 0.0522
Adult	0.0367 $\pm$ 0.0032	0.8040 $\pm$ 0.0767	0.7484 $\pm$ 0.0605
d.f.	4	8	8
t-value	0.6364 ^{NS}	1.3488 ^{NS}	1.4977 ^{NS}
Rohu			
Juvenile	0.0260 $\pm$ 0.0029	0.5790 $\pm$ 0.0477	0.5372 $\pm$ 0.0335
Adult	0.0327 $\pm$ 0.0035	0.7370 $\pm$ 0.0558	0.6460 $\pm$ 0.0421
d.f.	4	8	8
t-value	0.8341 ^{NS}	1.6508 ^{NS}	2.6899*
Catla			
Juvenile	0.0237 $\pm$ 0.0041	0.5392 $\pm$ 0.0305	0.4992 $\pm$ 0.0277
Adult	0.0307 $\pm$ 0.0041	0.7058 $\pm$ 0.0538	0.5978 $\pm$ 0.0332
d.f.	4	8	8
t-value	1.2298 ^{NS}	1.6006 ^{NS}	2.9586*

* = $P < 0.05$

NS = Non-significant

Fig. 9: Showing variation of arsenic residues in abdominal muscle of fish at different age (CC = Common carp, R = Rohu, Ca = Catla)



significant difference was found in any kind of goat of two age group (i.e. up to 2 years and more than 2 years) in Golgram and Hadipur-Jhikra-I G.P. whereas in Kolsur G.P. higher age group of buck and wether showed significantly ($P < 0.05$) higher value than lower age group. However, in case of female advanced age group showed higher value without significant difference.

4.3.3. Variation of arsenic residue with age in fish :

Table 28 showed the arsenic concentration of abdominal muscle of juvenile (3-6 months) and adult (more than 6 months) Common carp, Rohu and Catla. Statistical analysis revealed no significant differences of arsenic concentration between these age groups of all kind of fishes in Golgram and Kolsur G.P. In Hadipur G.P. though Common carp showed no significant difference but adult Rohu and Catla obtained significantly higher values ($P < 0.05$)

From the above discussion it is clear that in bird, goat and fish residual concentration of arsenic were higher with the advancement of age might be due to higher methylation capacity in younger one than that of their adult counter part and vice-versa (Yamauchi *et al.*, 1999). Results of present study supported the observation of Marafante *et al.* (1982), Kirova (1994) and Raie (1996).

4.4. Variation of arsenic residue with sex :

To describe the variation of arsenic residue with sex overall mean concentration of arsenic in liver in case of desi bird and goat of all age groups in each sex were chosen. Table 29 and Table 30 revealed that both in case of bird and goat there was no significant concentration of liver arsenic within sexes though in all species male showed higher values which were more pronounced at sexual maturity. Little variation was found between buck and wether. At sexual maturity female showed lesser concentration of arsenic than

Table 29 Mean $\pm$ SE with Test of significance of variation of arsenic residue in liver of desi bird at different age

	Hen	Cock	d.f.	t-value
Golgram (control)	0.0873 $\pm$ 0.0032	0.0872 $\pm$ 0.0040	10	0.3264 ^{NS}
Kolsur	1.7282 $\pm$ 0.1084	1.7793 $\pm$ 0.1137	18	0.0325 ^{NS}
Hadipur Jhikra-I	1.3408 $\pm$ 0.0858	1.4073 $\pm$ 0.0836	18	0.5553 ^{NS}

NS = Non-significant

Fig. 10: Showing variation of arsenic residue in liver of desi bird at different age

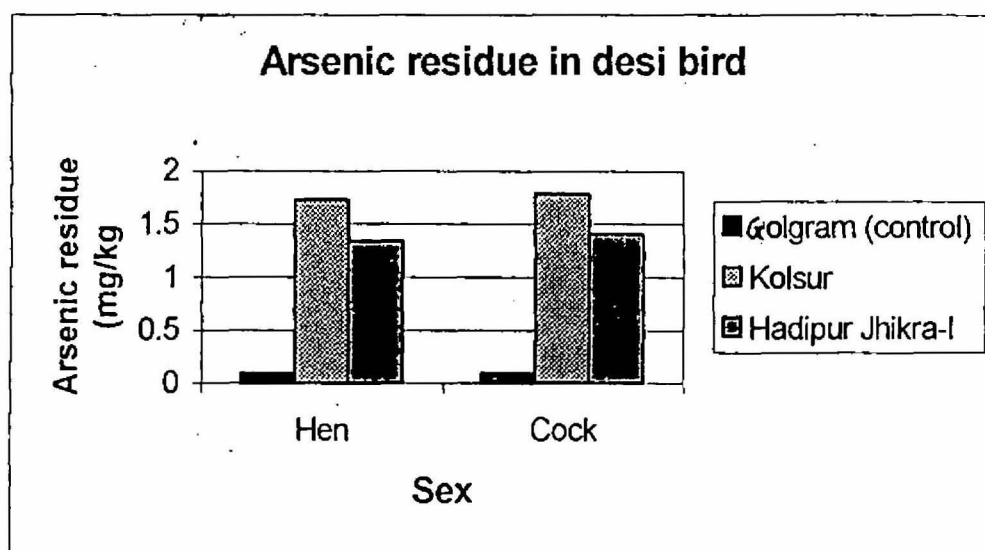


Table 30. Mean $\pm$ SE with Test of significance of variation of arsenic residue in liver of Bengal goat at different sex

	Buck	Wether	Doe	d.f. with t- value					
				d.f.	t ₁	d.f.	t ₂	d.f.	t ₃
Golgram (control)	0.0742 $\pm$ 0.0052	0.0727 $\pm$ 0.0053	0.0697 $\pm$ 0.0052	10	0.2026 ^{NS}	10	0.6142 ^{NS}	10	0.4057 ^{NS}
Kolsur	1.1416 $\pm$ 0.0952	1.1346 $\pm$ 0.0936	1.0355 $\pm$ 0.0696	18	0.0524 ^{NS}	18	0.8999 ^{NS}	18	0.8497 ^{NS}
Hadipur Jhikra-I	0.944 $\pm$ 0.0783	0.9416 $\pm$ 0.0748	0.9033 $\pm$ 0.0529	18	0.0288 ^{NS}	18	0.5024 ^{NS}	18	0.4994 ^{NS}

t₁ = Buck Vs. Wether, t₂ = Buck Vs. Doe, t₃ = Wether Vs. Doe

NS = Non-significant

Fig. 11: Showing variation of arsenic residue in liver of Bengal goat at different sex

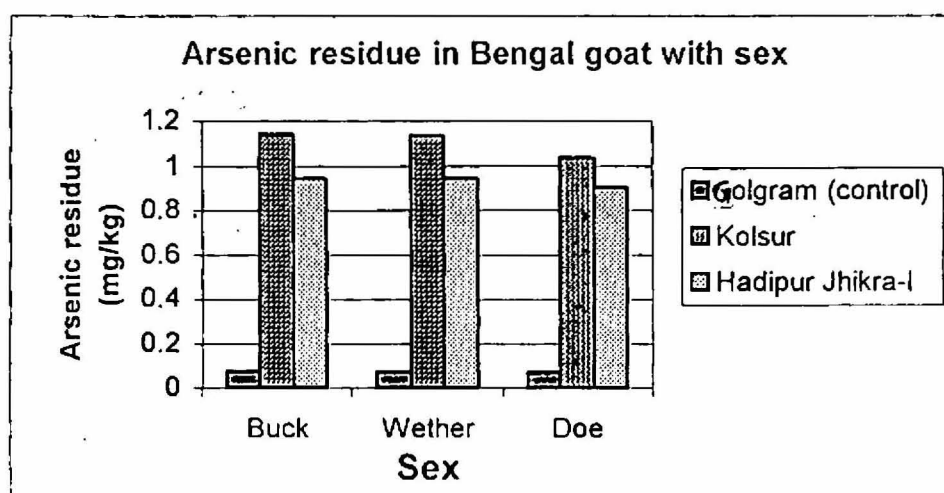


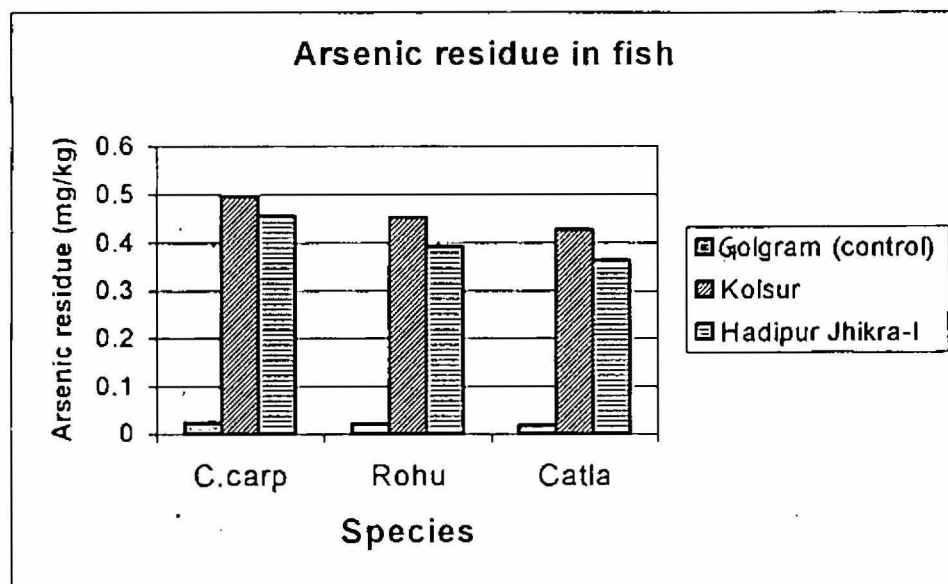
Table 31. Mean $\pm$ SE with Test of significance of variation of arsenic residue in abdominal muscle of fish of different species

	Common carp	Rohu	Catla	d.f. with t- value					
				d.f.	t ₁	d.f.	t ₂	d.f.	t ₃
Golgram (control)	0.0232 $\pm$ 0.0017	0.0210 $\pm$ 0.0008	0.0185 $\pm$ 0.0016	10	1.1482 ^{NS}	10	2.0061 ^{NS}	10	1.4315 ^{NS}
Kolsur	0.4959 $\pm$ 0.0453	0.4527 $\pm$ 0.0469	0.4274 $\pm$ 0.0337	18	0.7441 ^{NS}	18	1.2131 ^{NS}	18	0.5107 ^{NS}
Hadipur Jhikra-I	0.4565 $\pm$ 0.0364	0.3907 $\pm$ 0.0245	0.3626 $\pm$ 0.0215	18	1.4992 ^{NS}	18	2.2214 ^{NS}	18	0.8618 ^{NS}

t₁ = Common carp Vs. Rohu, t₂ = Common carp Vs. Catla, t₃ = Rohu Vs. Catla

NS = Non-significant

Fig. 12: Showing variation of arsenic residue in abdominal muscle of fish of different species



male, might be due to excretion of arsenic through egg in case of layer, (Donaldson and Braune, 1999, and Chiou *et al.*, 1997) and through milk as well as placental transfer (Stevens *et al.*, 1977) and also significant increase of urinary excretion might be due to hormonal effect (Concha *et al.*, 1998) in female.

4.5. Variation of arsenic residue with different fish species :

Here also abdominal muscle was chosen as an indicator organ of fish just like when variation of arsenic residue with age of fish was considered. Table 31 showed except Common carp and Catla in Hadipur G.P. no significant values were observed between any species of fishes under observation though Common carp tended to accumulate highest value followed by Rohu and Catla. This might be due to Common carp being bottom feeder and was subjected to be exposed with higher concentration of arsenic of pond sediment. The reason behind least concentration of arsenic in Catla was due to lowest concentration of arsenic in surface layer of pond water as noticed in the present study.

4.6. Pathomorphology :

Most of the animals were in subclinical stage (Fig. 13). Only few birds were showing symptoms of arsenicosis (Fig. 14) and the following macroscopic and microscopic changes were observed during pathomorphological examination of the birds.

4.6.1. Macroscopic pathology:

On opening the carcass the generalized picture was congestion, hyperemia and mild to extensive haemorrhages in different organs like lungs, liver, heart, spleen. The reason may be due to capillary endothelial cells of these organs are sensitive to arsenic and it causes

relaxation of capillaries and increase in capillary permeability (Hatch, 1984).

On opening the intestine the mucous membrane showed congestion and necrosis in a few places. (Fig. 16).

The liver showed discrete and large green foci throughout the surface (Fig. 15). Similar type of lesion was also seen by Shapiro *et al.* (1992).

4.6.2. Microscopic pathology

4.6.2.1. Lungs :

The section of the lung showed extensive congestion and haemorrhages along with pneumonic changes (Fig.17). The haemorrhages was seen in the alveoli as well as in the inter alveolar spaces. In some areas of the lungs, thickening and proliferation of the inter alveolar connective tissue was seen. Sometimes bronchiectasis, laryngotracheitis and metaplasia of bronchial epithelium was seen, corroborate with the findings of Prier *et al.* (1963) in rat.

4.6.2.2. Liver :

The section of liver showed extensive haemorrhages throughout the parenchyma along with coagulative necrosis in focal areas (Fig. 18). There was swelling of the hepatocytes near central vein. In some places periportal cirrhosis was observed. A marked pathological changes was observed in small as well as in large bile ducts. Small bile ducts showed degenerative changes and large bile ducts showed proliferative changes. In some large bile ducts necrosis was observed. The findings were in agreement with the observation of Von glahn *et al.* (1938) in rabbit, Byron *et al.* (1967) & Carmignani *et al.* (1983) in rat and Shapiro *et al.* (1992) in broiler chicken.

4.6.2.3. Heart :

The section of the heart showed derangement of myocardial fibres. The endothelial cells of coronary vessels showed degenerative changes along with extensive haemorrhage (Fig. 19).

4.6.2.4. Proventriculus and Gizzard :

There was intensive inflammation of the proventriculus & gizzard. Horny lining of the gizzard was sloughed off, corroborated with the observation of Hatch (1984).

4.6.2.5. Intestine :

The alimentary canal showed congestion and haemorrhage in many places. Necrosis of the villi was observed and the necrosed epithelium sloughed off from their base and accumulated in the lumen (Fig. 20) which is supported by the observation of Hatch (1984). According to him, the reason behind the sloughing of the mucosa is due to accumulation of fluid in the submucosa.

4.6.2.6. Spleen :

The section of the spleen showed moderate congestion.

4.6.2.7. Kidney :

The section of the kidney showed profuse haemorrhage and fibrosis in the inter tubular space (Fig. 21). Hyaline casts were observed in straight tubules and swelling of the epithelium of the convoluted tubules which is supported by the findings of Fairhall and Miller (1941) and Prier *et al.* (1963). In the present study dilatation of the tubules were observed in cortical and medullary regions. Glomeruli showed mild degenerative and cystic changes, which corroborated with the findings of Pierce *et al.* (1963).

4.6.2.8. Uterus :

The section of the uterus showed mild haemorrhage.

4.6.2.9. Ovary :

The section of the ovary showed great thickening of the stroma. Ovarian follicle showed no changes. (Fig. 22).



Fig. 13: Showing hen, without any external symptoms, collected from a woman having spotted keratosis in palm



Fig. 14: Showing peripheral nervous symptoms of arsenicosis in a broiler bird

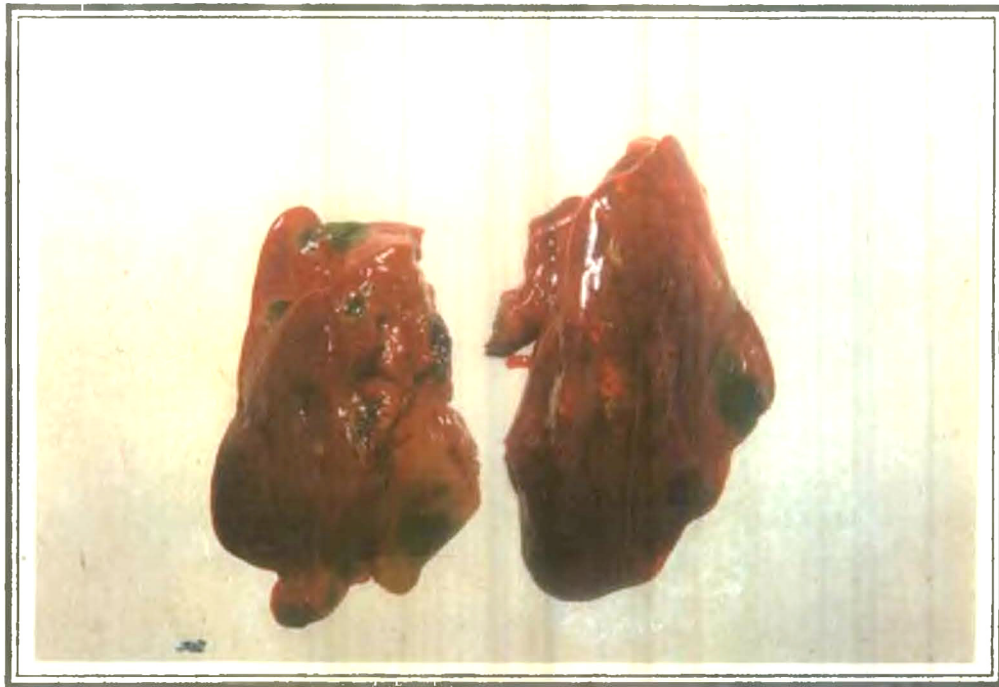


Fig. 15 : Showing discrete and large green foci throughout the surface of liver



Fig 16 : Showing haemorrhages in the intestine after opening the carcass

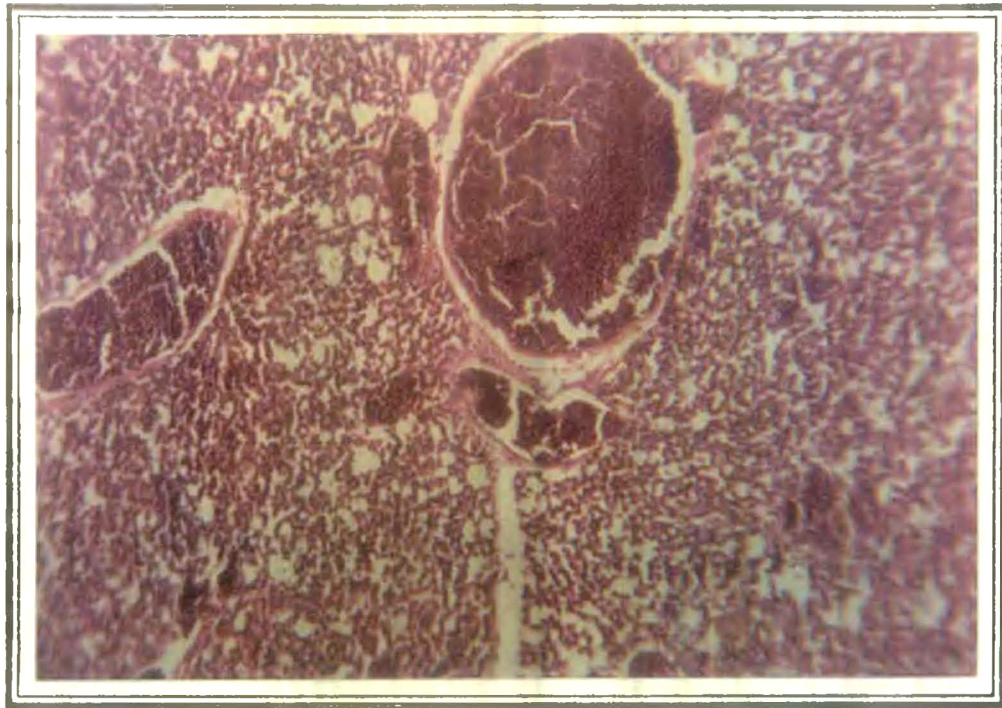


Fig. 17: Showing extensive congestion and haemorrhage along with the pneumonic changes in the section of the lung; H.& E., 100 X.

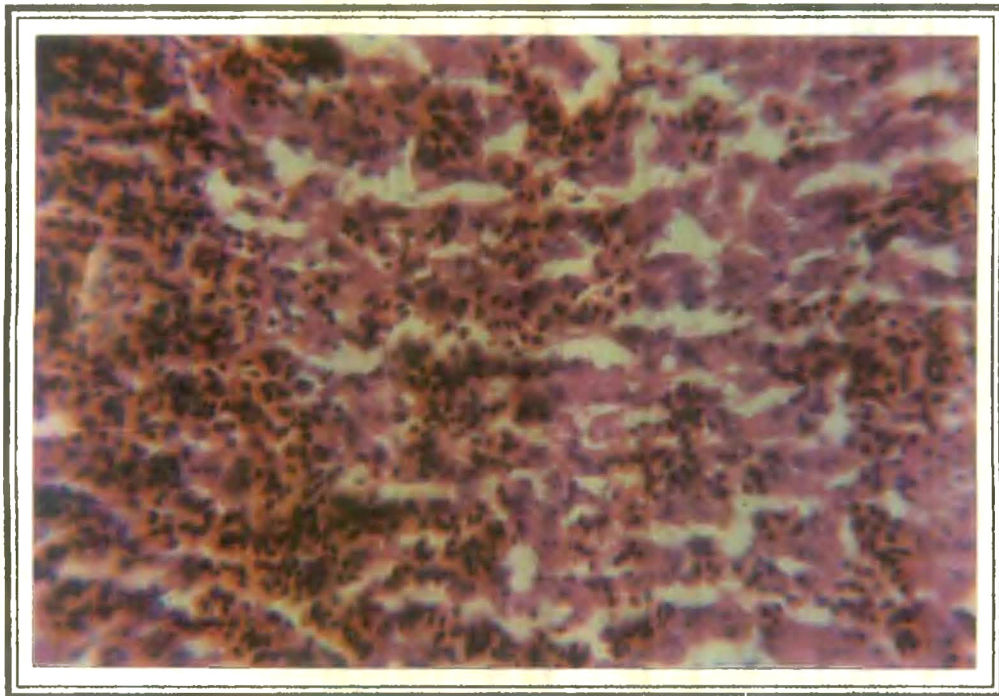


Fig. 18: Showing extensive haemorrhage through out the parenchyma along with coagulative necrosis in focal areas in the section of liver; H.& E., 450 X.

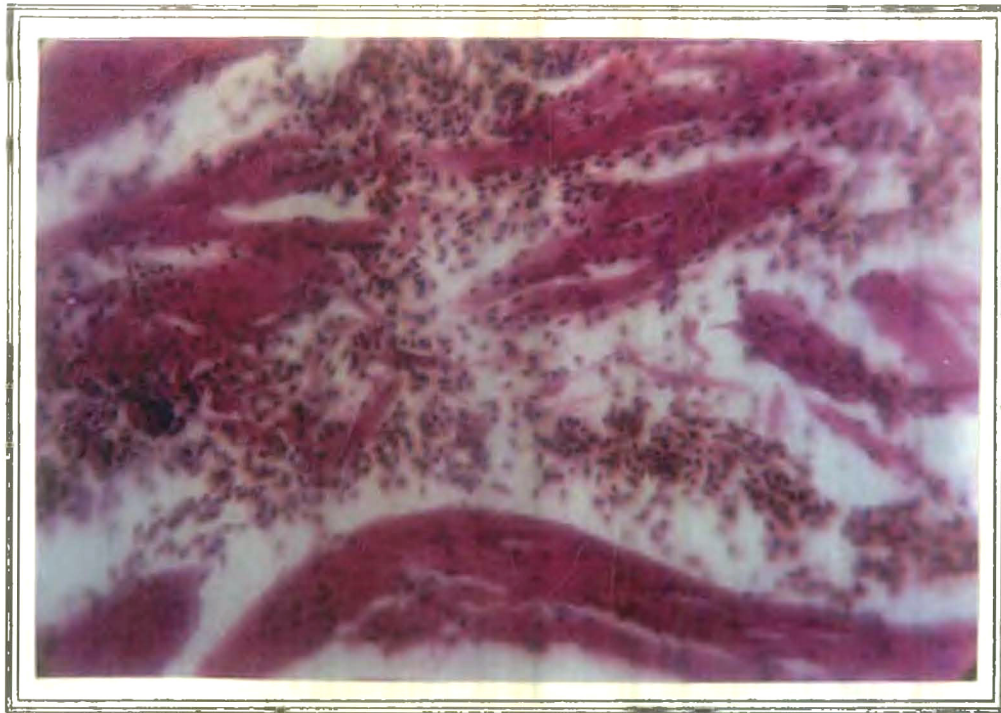


Fig. 19: Showing derangement of myocardial fibres and extensive haemorrhage in the section of the heart; H.& E., 450 X.

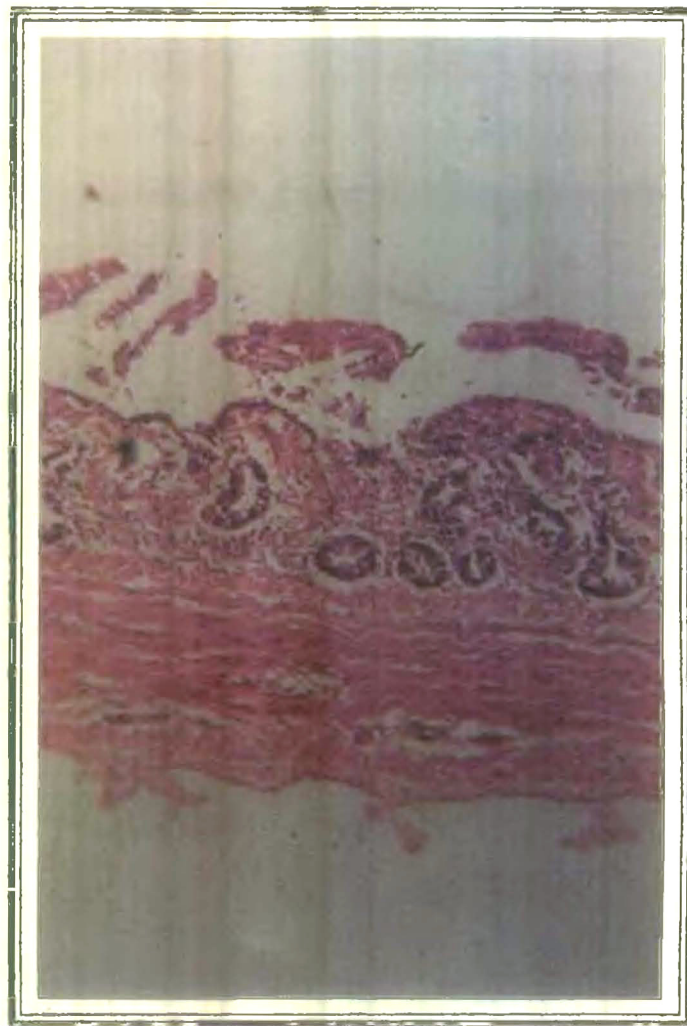


Fig. 20: Showing necrosis of villi and the necrosed epithelium sloughed off from their base and accumulated in the lumen in the section of the intestine; H.& E., 100 X.

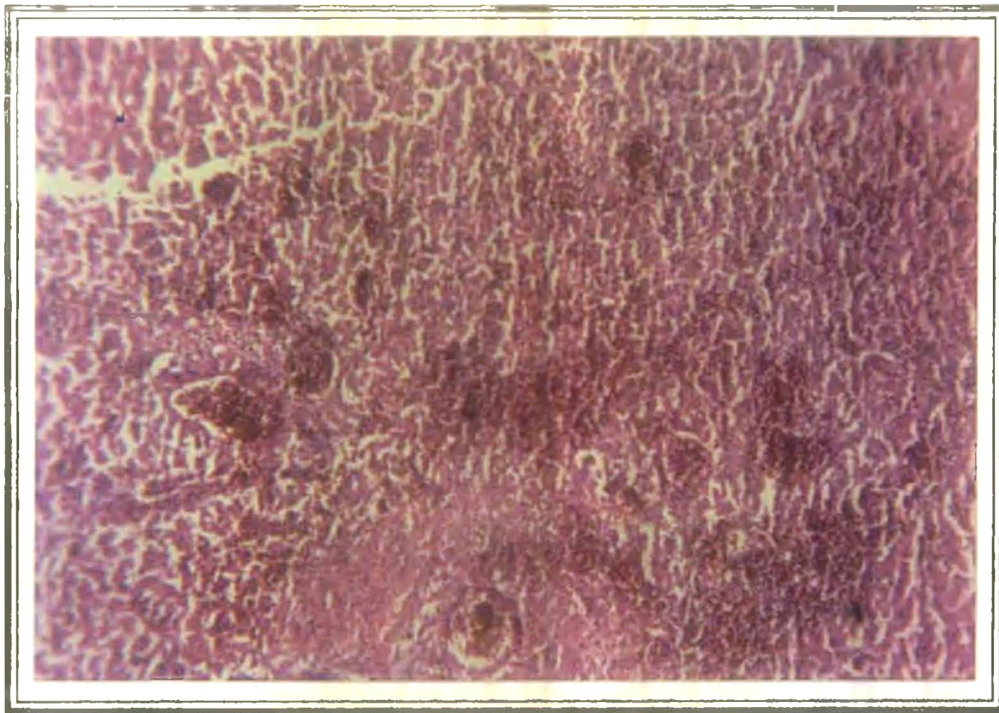


Fig. 21: Showing profuse haemorrhage in the intertubular space and fibrosis in the section of the kidney; H.& E., 100 X.

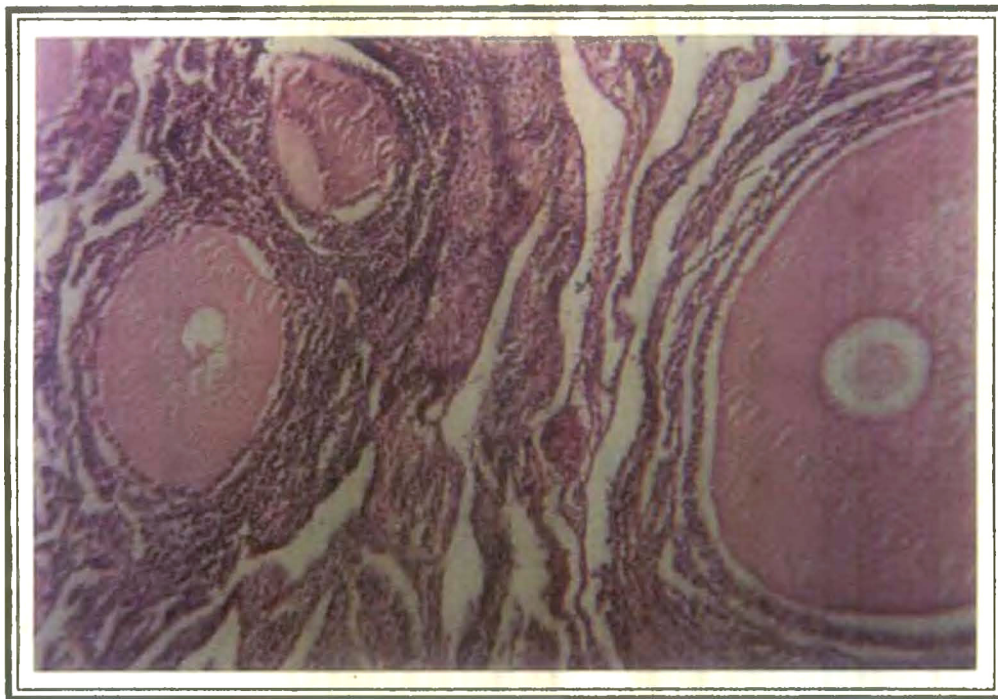


Fig.22: Showing great thickening of the stroma without changes in the follicle of the ovary; H.& E., 100 X.

4.7 Human health hazard through consumption of animal and fish products along with the drinking water:

To assess public health impacts associated with arsenic in animal products along with the drinking water, it is important to estimate human exposure to the metalloid via animal products and drinking water consumption. In the present study, the mean arsenic concentration was detected in different animal products of different G.P. (Table 32). Though the concentration did not exceed the Indian maximum permissible limit (MFPO Amend in 1992) but it had a definitely contributory function regarding the human health hazard.

Based on animal products consumption rate (Table 33) in West Bengal, the daily intake of total and inorganic arsenic (Table 34 & Table 35) through the ingestion of animal products was determined. It was found that contribution of arsenic from animal products alone did not exceed the WHO provisional tolerable daily intake of 100 µg (WHO, 1983) in any G.P.

Table 36 showed a comparative study of total arsenic and inorganic arsenic intake by the people of two affected G.P. (i.e. Kolsur and Hadipur-Jhikra-I) of Deganga block with the people of unaffected block, Golgram. From the results of the total amount of arsenic consumed both through animal products (meat + fish + egg + milk) and drinking water, the body burden of arsenic to Golgram, Kolsur and Hadipur-Jhikra-I villagers was 7.2349, 1167.3757 and 506.7428 µg per capita per day respectively. So when considering the contribution of total arsenic of animal products along with the drinking water it was much higher than WHO provisional tolerable daily intake i.e. 100 µg.

It was also found that most of the arsenic coming from drinking water and food, except fish, was inorganic in nature (Table 33). As the toxicity of most of the inorganic arsenic compounds in food and drinking water was more than that of the organic arsenic, the people of affected G.P. appeared at risk from arsenic. According to WHO (1981), 1 mg of inorganic arsenic per day may give to skin lesions within a few years. Result showed that the contribution of inorganic arsenic through animal products and drinking water in Kolsur was

Table 32. Mean $\pm$ SE of arsenic concentration in different animal products and drinking water

Item	Golgram (Control)	Kolsur	Hadipur-Jhikra-I
Arsenic in meat* ($\mu\text{g/g}$)	0.0433 ± 0.0023	0.7001 ± 0.0465	0.5792 ± 0.0276
Arsenic in fish* ($\mu\text{g/g}$)	0.0180 ± 0.0011	0.3930 ± 0.0243	0.3368 ± 0.0231
Arsenic in egg* ($\mu\text{g/g}$)	0.0247 ± 0.0020	0.2752 ± 0.0241	0.2450 ± 0.0239
Arsenic in milk* ($\mu\text{g/g}$)	0.0015 ± 0.0002	0.0073 ± 0.0010	0.0060 ± 0.0040
Arsenic in drinking (grund) water ($\mu\text{g/ml}$)	0.0020 ± 0.0006	0.3828 ± 0.0687	0.1636 ± 0.0328

- * Meat = Mean of meat of all age group (except 25-30 days old broiler) of all classes of broiler, desi bird and Bengal goat.
- * Fish = Mean of fish flesh of all age group of 3 different species of fish under sampling.
- * Egg = Mean of whole egg.
- * Milk = Mean of cow and goat milk.

Table 33. Consumption rate of different animal products and drinking water (per capita per day basis) in West Bengal and percentage of inorganic arsenic in them

Subject	Meat	Fish	Egg	Milk	Drinking (grund) water
Per day per capita consumption in West Bengal	15g ^a	15.67g ^b	5.22 g ^a	119.5 g ^a = 116.36 ml	3000 ml
Percentage of inorganic arsenic	75 ^c	3 ^d	65 ^c	75 ^c	100 ^e

^a Source : Pranisampad (1999)

^b Source : Hand Book of Fisheries Statistics (1996)

^c Source : Yost *et al.* (1998)

^d Source : Koch *et al.* (2001)

^e Source : Irgolic *et al.* (1983)

**Table 34. Contribution of total arsenic through different animal products
(per capita per day basis)**

Subject	Golgram	Kolsur	Hadipur-Jhigkra-I
Contribution of total arsenic per day through meat (μg)	0.6495	10.5015	8.6880
Contribution of total arsenic per day through fish (μg)	0.2820	6.1583	5.2777
Contribution of total arsenic per day through egg (μg)	0.1289	1.4365	1.2789
Contribution of total arsenic per day through milk (μg)	0.1745	0.8494	0.6982
Total contribution of arsenic through animal products (μg)	1.2349	18.9457	15.9428

Table 35. Contribution of inorganic arsenic through different animal products (per capita per day basis)

Subject	Golgram	Kolsur	Hadipur-Jhigkra-I
Contribution of inorganic arsenic per day through meat (μg)	0.4871	7.8761	6.5160
Contribution of inorganic arsenic per day through fish (μg)	0.0085	0.1847	0.1583
Contribution of inorganic arsenic per day through egg (μg)	0.0838	0.9337	0.8313
Contribution of inorganic arsenic per day through milk (μg)	0.1309	0.6371	0.5237
Total contribution of inorganic arsenic through animal products (μg)	0.7103	9.6316	8.0293

Table 36. Contribution of total and inorganic arsenic through drinking and different animal products (per capita per day basis)

Subject	Golgram	Kolsur	Hadipur-Jhigkra-I
Contribution of total / inorganic arsenic per day through drinking water (μg)	6	1148.4	490.8
Total contribution of arsenic through animal products and drinking water (μg)	7.2349	1167.3757	506.7428
Total contribution of inorganic arsenic through animal product and drinking water (μg)	6.7103	1158.0316	498.8293

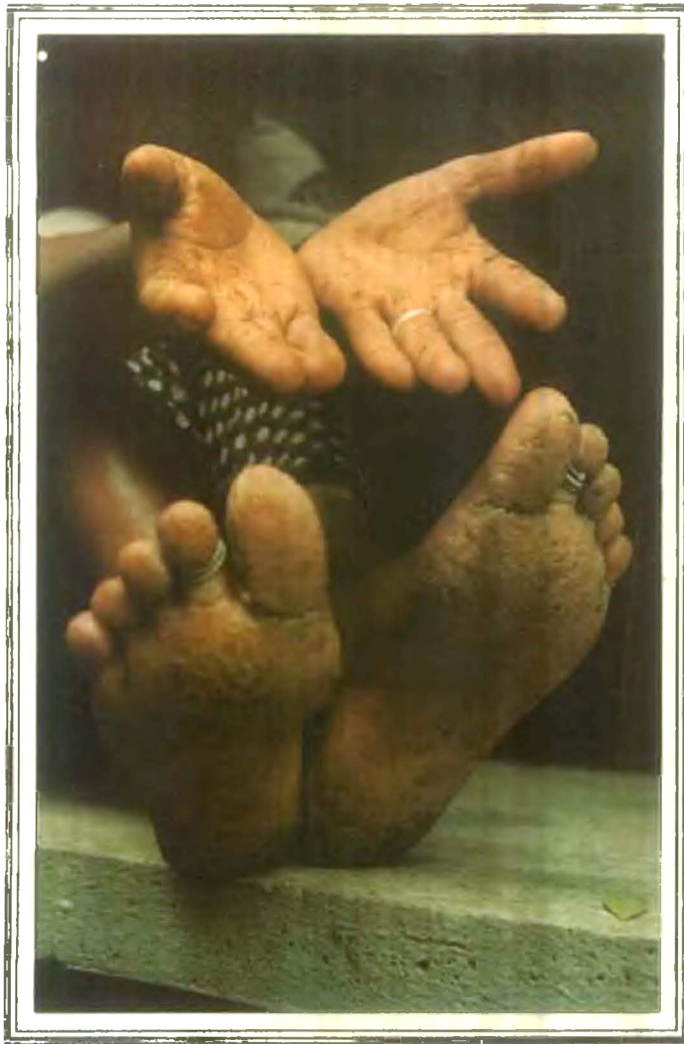


Fig. 23: Showing palmo-planter hyperkeratosis in a twelve year old girl of Kolsur G.P.

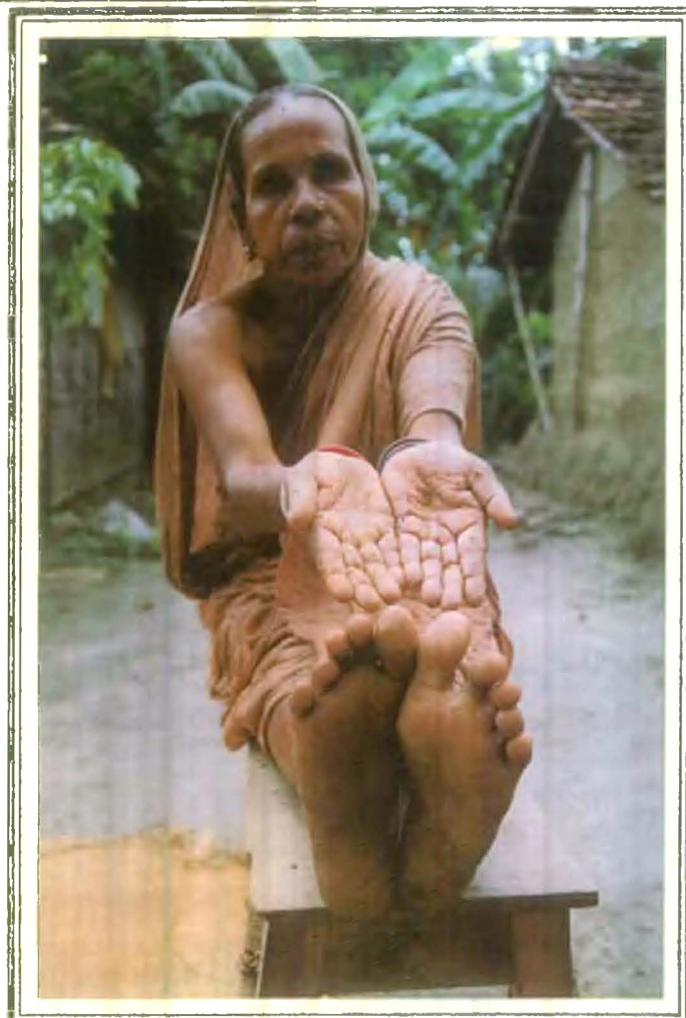


Fig. 24: Showing arsenical dermatosis with loss of sight in an aged woman of Kolsur G.P.

more than the 1 mg and a good percentage of people were suffering from skin lesion (Fig. 23 and Fig. 24). It has been estimated that based on the current U.S. Environmental protection Agency (EPA) standard of 50 μg /l, the lifetime risk of dying from cancer of the liver, lung, kidney or bladder from drinking 1 litre/day of water could be as high as 13 per 1000 persons (Smith et al., 1992). In the latest document on arsenic in drinking water, the U.S. National Research Council (1999) concluded that exposure to 50 μg /l could easily result in a combined cancer risk of 1 in 100. Comparing the values in the WHO, EPA documents and present findings it was appeared that there was risk of suffering from arsenical skin lesions and cancer in the villagers of Kolsur and Hadipur-Jhikra-I G.P. It was also corroborate with the observation of Chowdhury et al. (1994) who reported that more than 80% people had arsenical lesions in Karmakarpara of Shanpukur village in Hadipur-Jhikra-I Gram Panchayet and 22.9% people diagnosed with clinical manifestation in Fakirpara of Uttarkolsur village in Kolsur Gram Panchayet (Chowdhury et al. (2001). So it is obvious from present findings that animal products might have a significant contribution of arsenic to produce clinical manifestations in human being of affected areas.

CHAPTER V

SUMMARY AND CONCLUSION

Summary and Conclusion

Ground-water arsenic contamination and human suffering are increasing in West Bengal and Bangladesh. In arsenic - affected areas tons of arsenic is falling on agricultural land using water from arsenic - contaminated tubewells for its cultivation. Not only that, surface water is also being polluted by arsenic contaminated run off water from irrigated agricultural land. Thus arsenic is coming in elevated level in the food chain by polluting aquatic and terrestrial biota. This does not mean every aquatic and terrestrial biota living in the polluted environment will show clinical symptoms. Thus it is expected being subclinically affected they will take share to cause arsenicosis in human being through food chain. Hence, the present studies were planned with objectives to generate information on arsenic profile in some selected elements of environment as outlined below:

- 1) To study the level of arsenic in different terrestrial and aquatic elements.
- 2) To study the distribution of arsenic in different organs, products and excreta of the animals.
- 3) To study the human health hazards through consumption of animal products and fish.
- 4) To study the effect of rearing system, species, sex and age of the selected biota on deposition of arsenic.
- 5) To study the pathomorphological changes in animals.

In the present study, the elements selected for arsenic estimation were ground and surface water, pond sediment, soil and different feed, forages, tree leaves, birds, goats, fishes and their products like egg and milk. The parameters studied under this experimentation were rearing system, sex and age in case of bird, sex and age in case of goat (Bengal goat) and species and age

in case of fish. The elements were taken from purposively selected two blocks, one affected block (Deganga, North 24 Parganas) and another unaffected block (Golgram, Paschim Midnapore). The farmers have been identified selectively and randomly keeping in view that all the parameters under study should have with them.

In the present study spectrophotometry using silver diethyldithiocarbamate complex of arsenic was adopted for determining the arsenic level in different elements.

Results of the present study can be summerized as :

1. Arsenic content in ground and surface water of both affected Gram Panchayet were not only more than that of arsenic content of unaffected G.P. but also beyond the permissible limit of 0.05 mg/l as suggested by WHO.

2. Pond sediment and soil contained much higher concentration of arsenic than that of control area.

3. All the forages and plant leaves contained a very high value of arsenic in affected area but there was no marked difference of arsenic concentration in broiler feed between the affected and unaffected area.

4. Regarding the deposition of arsenic in different organs it was found that keratinized tissue like hair / feather / scale, hoof / claw / fin contained highest level of arsenic.

5. Among the edible parts, other than the skin in case of birds, liver contained highest concentration of arsenic of all species, age and sex group.

6. It was also found that in case of birds and goats thigh muscle contained more arsenic concentration than breast muscle. Whereas in case of fish abdominal muscle contained greater concentration of arsenic than dorsal muscle irrespective of species and age group.

7. Again it was found that female reproductive organ (i.e. ovary) deposited higher level of arsenic than the male reproductive organ i.e. testis.

8. Among the organs, the least concentration of arsenic was found in brain of all animals.

9. Among the different components of blood, it was cleared that the blood cell has a tendency to accumulate more arsenic, near about 3 times than the plasma.

10. It was found that arsenic content was high in urine and faeces in younger age group than the adult one and the level of arsenic in these excreta may be considered as indicator of arsenic exposure.

11. The result showed that animal products like milk and egg also contained arsenic but milk seemed to have least concentration which may be considered safe for human consumption. Among the different components of egg, yolk showed the highest concentration of arsenic and shell showed least. The ratio of arsenic content in whole egg, yolk and albumin was about 2:3:1.

12. When rearing system of the birds was considered, it was found that desi birds being sacrificed in much more advanced age group contained higher level of arsenic residue but that was not upto the much higher level than broiler which are reared in intensive system and fully provided ground water for drinking.

13. Regarding the variation of arsenic residue with ageing it was found that in all types of birds, goats and fishes arsenic deposition tended to be higher with the advancement of age. Again when sex was considered, it was revealed that the deposition of arsenic in male was in higher level than the female counterpart.

14. In fish it was found that common carp being bottom feeder accumulated highest level of arsenic than the other two species i.e. rohu and catla.

15. Pathomorphological examination revealed that there was generalised picture of congestion, hyperemia and mild to extensive haemorrhages in different organs. Besides there was pneumonic change in lungs, coagulative necrosis and bile duct proliferation in liver, derangement of myocardial fibres, sloughing off horny lining of gizzard and mucosa of intestine.

16. To assess public health impacts, it was found that though the concentration of arsenic in meat, fish, egg and milk were below the level of Indian maximum permissible limit i.e. 1 mg/kg, but long term consumption of that contaminated products may definitely have a contributing role on chronic arsenicosis in human being.

So, it can be concluded that besides contaminated drinking water the contribution of arsenic from animal products in the affected area may also cause human health hazard. Furthermore products from animal sources containing elevated level of arsenic are being sold at the common market place, and even people who are not drinking arsenic contaminated water may get arsenic from these animal products. Such exposure of arsenic in a very minute level causes chronic arsenicosis of the individuals. The total effects of arsenic i.e. from drinking water and sources of animal products are many a time dangerous for animal health as well as for human health. The block of Deganga is an example of many such blocks in West Bengal and Bangladesh and results of such work could give a glimpses of the situation in some areas of arsenic affected areas where more elaborate study should be conducted to understand the catastrophe of the situation.

CHAPTER VI

FUTURE SCOPE OF RESEARCH

Future Scope of Research

- 1) The study on the status of arsenic in different elements of environment was under taken only in two blocks of West Bengal, one was in affected and another was in unaffected areas. To have a prefect conclusive picture on arsenic profile in West Bengal, the area of the work and population size should be expanded.
- 2) Characterization of exposure to and bioavailability and toxicity of different arsenic species in foods, as well as variation in the levels of arsenic species in the same food items from different geographical areas should be standardized.
- 3) Possible effects of chronic arsenicosis of different terrestrial and aquatic species should be determined, particularly in terms of production of agricultural and animal resources both quantitatively and qualitatively.
- 4) The effects of chronic arsenicosis should be investigated on reproductive performance, embroynic development both in animal and human being.
- 5) Influence of arsenic contaminated animal products as a source of protein to mitigate arsenic burden vis a vis as a source of arsenicosis in human being should be evaluated through robust, sensitive and accurate analytical technique.
- 6) ~~6) Adequate resources~~ ^{should be find out} to prevent such problem with least involvement of fund suitable for the affected mass.

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* Original not seen