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Phenolic Ecotoxins in River Water: Survey on Knowledge and Practices of Road-Side Food Vendors Operating Along River Chania Bank Fringes in Thika Sub- County, Kenya

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Abstract

Purpose: Phenolic ecotoxins consumed in raw surface water from river sources has been implicated in causing diseases of high burden such as cancers, in Kenya. This study was conducted in Thika Sub County, and data collected from roadside food vendors and food hawkers who operate small scale street food business along the fringes and banks of River Chania. The study's objective was to establish the knowledge on Phenolic ecotoxins present in river water and practices of the study respondents.

Methodology: A crossectional descriptive study design was used, in which combined interviews and questionnaire enquiries conducted from, n=341, small-scale road side food vendors and hawkers was analyzed.

Findings: Data reveals that none of the respondents had knowledge on Phenolic ecotoxin contaminants and additionally a strongly associated correlation (P<0.001, $\chi^2$22.6 and df 1), further augments the disclosure that, poor knowledge of raw river water safety and hygiene does result to body harm and ill health.

Unique Contribution to Theory, Policy and Practice: There is increased need and effort to scale up the sensitization and awareness on exposure to harmful ecotoxin contaminants from the use of raw river water. Water decontamination mobile units should be considered and introduced especially in urban areas of high population density, transversed by rivers.

Keywords: *Knowledge, Practices, Phenolic Ecotoxins, River Chania, Roadside Food Vendors/Hawkers*

Introduction

Water supports life and without this essential commodity, it would virtually be impossible for the existence of organisms, be it human beings, animals and plants. It has been approximated that 1.1 billion people have shortage of clean water free from toxic contaminants, and a further 2.4 billion have inadequate access to proper sanitation system, especially in developing countries.

In peri-urban settlements where rivers intersect and transverse across the landscape, increasing human activities from mining, agribusiness, manufacturing and socio-economic ventures resulting to population growth, have contributed to pollution and contamination of river water via leaked toxic inorganic and organic pollutants. Pollution of water is a serious global challenge, and is one of the leading worldwide geneses of disease morbidity and mortality from drinking contaminated water. The demand for clean water increases with the expansion in the population growth, occasioned by rising human economic activity and industrialization.

In Kenya, there are several urban and peri-urban town centers where rivers transverse through in their path or course of flow. In the capital city of Nairobi, the Nairobi River and its tributaries, serves as a water source to communities along its banks, and similarly, River Chania and its tributaries in Thika Town, is of economic importance to many small-scale road side food vendors and hawkers who sell ready to eat cooked snack. These hawkers of snacks “on-the-go” who operate businesses that require water use, sell boiled eggs, arrow root, yams, sausage smokies, and sliced fruit sellers such as water melons. Some of the small-scale food sellers and road side food vendors, have set up temporary make-shift stalls and sheds, on the fringes of River Chania banks, and use the river as their source of water for their economic activities [1]and [2].

Thika town, the Sub-county’s central business district is an industrial hub to many factories and industrial plants, whose waste material may sometimes leak in underground channels into River Chania especially in run-off surface water during torrential rain and flooding seasons. The use of raw river water poses an exposure risk to the communities who use this water due to the presence of many contaminants such as heavy metals, toxic and carcinogenic compounds and even pathogenic microbiome [3]. Some of these compounds are disintegrated into toxic simple moieties which remain poorly biodegraded and are highly carcinogenic. Pollutants such as Phenols and catechols are hematotoxic and hepatotoxic and provoke mutagenesis and carcinogenesis in animal and human tissues and cells [4] and [5].

The study’s objective was to establish the knowledge of Phenolic ecotoxins present in raw river water, and also knowledge of general safety and potential body harm of using raw River Chania water by the roadside food vendors and hawkers. Subsequently strategies and measures to remove and extract these compounds from raw water can be explored [6].

Literature review

Pollution of the environment is of worldwide concern due to its negative impact, not only to the risk posed to human wellness but also in causing climate change. The biodiversity of veterinary, wildlife, avian and marine life is also not spared from harm, where industrial waste may leak into the water bodies such as rivers and lakes that serves as a source of water for their drink. It is reported that there's a global decline in biodiversity wildlife populations, to the point of some organisms being declared endangered species all attributed to exposure to Phenol ecotoxin contamination.

In Kenya, human activity is widespread and extensive especially where rivers run their course and pathways. This poses a risk of river water contamination from liquid and solid wastes emanating from human socio-economic activities, as well as from local small-scale industrial manufacturing processing plants [1]. Human activities involving the use of river water in river banks, such as washing of clothes, car wash and motorbike cleaning services in the river, bathing and not limited to farming significantly contribute to polluting river water. River Chania is a typical example of a river, whose water flow and course is in close proximity to where human activities are active and extensive in Thika Sub County. The river which originates from the water towers of the Aberdare Ranges runs its course downstream transversing Thika Town, which serves as the Central Business District hub of Thika Sub County. It has several tributaries that feed into it such as Thika, and Karimenu Rivers, hence has enough water that supports domestic and socio-economic life for Thika residents. Several manufacturing industries, residential flats and estates including some community semi-formal settlements and villages are located along R. Chania banks, therefore making the river a dumping ground for industrial waste, human sewerage and domestic refuse. The water from this river is grossly polluted with rubbish, plastics, solid and liquid wastes and human sewerage [1].

Phenolic ecotoxins have been identified in Kenyan water bodies, and more so in abundant quantities in most rivers [1]. Surface run-off water from various sources such as excess water from rainy season, irrigation schemes water outlet, large-scale commercial farming, and industrial liquid and solid waste effluent which all drain their water into the river, mostly influenced by steep and sloppy terrain and gravity forces [5].

River water is as key water source for domestic utility in most homesteads of the community, but often times its safety for use is usually questionable and compromised owing to the many diverse tributary sources that drain into the water bodies that form major rivers. According to the Kenya Water and Sanitation regulatory board (WASREB), the acceptable safe quantities of Phenolic compounds in drinking and bottled water is 0.002 Mg/L [7]. In River Chania these quantities are reported to be higher than the recommended WHO levels [1] and [2].

Phenolics are industrial substances of ambient concern because they are essential and used in many industrial processes such as in the manufacture cosmetic products, resin production, herbicides, pesticides, dyes, plastics polymers, refineries, explosives and pharmaceuticals, but

adversely, are also present as industrial waste from industrial processes. Some Phenolics polymers are used in chemical synthesis as well as solvents in large quantities. Because of their poor biodegradability, high degree of environmental toxicity may occur.

The search for appropriate approaches to solve the challenge of human ecotoxin exposure and contamination, from Phenol-like and Phenolic compound from surface water used for drinking and domestic uses is necessary.

Materials and Methods

Study design: Cross-sectional, descriptive study conducted between June 2021-November 2023.

Study location: Sampled sites along R. Chania banks, and R. Chania tributaries (R. Thika, and R. Karimenu) on the fringes of Thika Sub- County, where presence of human socio-economic activities was evident.

Study site: Chania Bridge, Ol-Donyo Sabuk village Centre, Ngoingwa Estate, Thika town Grogon auto mechanic sheds and Karimenu village.

Sampling size determination: The *Leslie-Fischer* formula was used for the sample size derivation ($n=Z^2Pq/d^2$)

n=Desired Sample size

P=Assumed population (Estimated population of street food hawkers and food vendors or Population prevalence of Thika Sub county street food hawkers/food vendors (5000)

Z= S.D. computed at 1.96 when the margin of error/degree of accuracy (d) is 5% (0.05) at the confidence Interval of 95%

q=Constant given at (1-P) or 1-5000

d=margin of error/degree of accuracy given at 5% (0.05)

Therefore the study computed this as;

$$n = \frac{1.96^2\,(5000)\,(1-5000)}{0.05^2}$$

$$n = 357$$

Some 16 questionnaires were incomplete having non-responses, hence at final analysis a total of **n=341** respondent output were considered.

Study population: Roadside food vendors, 341 respondents≥18-≤42 years.

***Data collection*:** Demographic and essential data was collected from simultaneous open-ended questionnaire queries and in person interviews.

Statistical analysis: Cleaned data was analyzed using the IBM SPSS version 25.0 (IBM Corp, Armonk, NY, USA). Analysis for associations and patterns of categorical variables was done using the Pearson's Chi square test and subsequent multivariate regression test, whereas the continuous variables were analyzed using the ANOVA test. Adjusted Odds Ratios (AOR) was estimated at 95% confidence interval and a *P value of <0.05* was considered as significant.

Ethical considerations: Ethical approval for the study was obtained from Mount Kenya University as an extension of the larger study on Cancer morbidity and mortality rates between the years 2013-2020 in Thika Level Five Teaching and Referral hospital, Kiambu County, Kenya (MKU/ERC/1241). Approval and funding to undertake the study was sought from Murang'a University of Technology (MUT/VCG/DVC-ASA/106/2019/VOL1). The research was conducted in accordance with the Helsinki declarations [8], and all the respondents' provided informed consent before enrollment into the study with confidentiality ensured throughout the study.

Results

Table 1 illustrates that of the 341 respondents, a large proportion of respondents were aged between 23-27 years old (32%) and 18-22 years old (29%) respectively. Over half of the respondents operated ready to eat boiled eggs and smokies (75.4%) and only 5 (1.5 %) constituted mobile hot beverage vendors that were temporarily stationed at the river bank as they are highly mobile selling their beverage products in other sites to chance passer by customers. More than half (54%) had secondary (2^0) school level of education, while 5 (1.5%) had never attended any formal schooling. Those who were in informal or self-employment occupations constituted 263 (77.1%), and only 78 (22.9%) were employed or salaried.

Table 1: Socio-demographic characteristics

Characteristics	Proportion (n)	Percentage (%)
Age		
<18	16	4.7
18-22	99	29
23-27	109	32
28-32	83	24.3
33-37	28	8.2
38-42	6	1.8
Total (N)	341	100
Marital status		
Married	73	21.4
Single	130	38.1
Divorced/Separated	138	40.5
Total (N)	341	100
Gender		
Male	101	29.6
Female	240	70.4
Total (N)	341	100
Level of education		
None	5	1.5
Primary (1^0)	92	27
Secondary (2^0)	185	54.3
Tertiary (3^0)	59	17.3
Total	341	100
Employment Status		
Not employed (self-proprietor)	263	77.1
Employed	78	22.9
Total	341	100
Type of operated Business		
Boiled Egg/Smokies, arrowroots vendors	257	75.4
Fruit slices/Fruit salad vendors	79	23.2
Mobile hot beverage/hawker	5	1.5
Total (N)	341	100
Religion		
Islam	52	15.2
Christians	275	80.6
Other	14	4.1
Total	341	100

On the practices of River Chania raw water use, for their activities, data analyzed from the 341 respondents indicated that 109 (31.7%) use river water daily, as shown in Figure 1, While 91 (26.7%) use river water twice in a week with a similar proportion of 91(26.7%) who use both river water and municipal water interchangeably, 38 (11%) responded that they

use river water when the Municipal water is not available or when their meter is disconnected, while 9 (3%) responded that they use the water for cleaning and washing only but not for drinking.2 (0.6%)prefer to buy water from safe source (Municipal metered water). 1 respondent, (0.3%) preferred not to disclose their source of water, Figure 1.

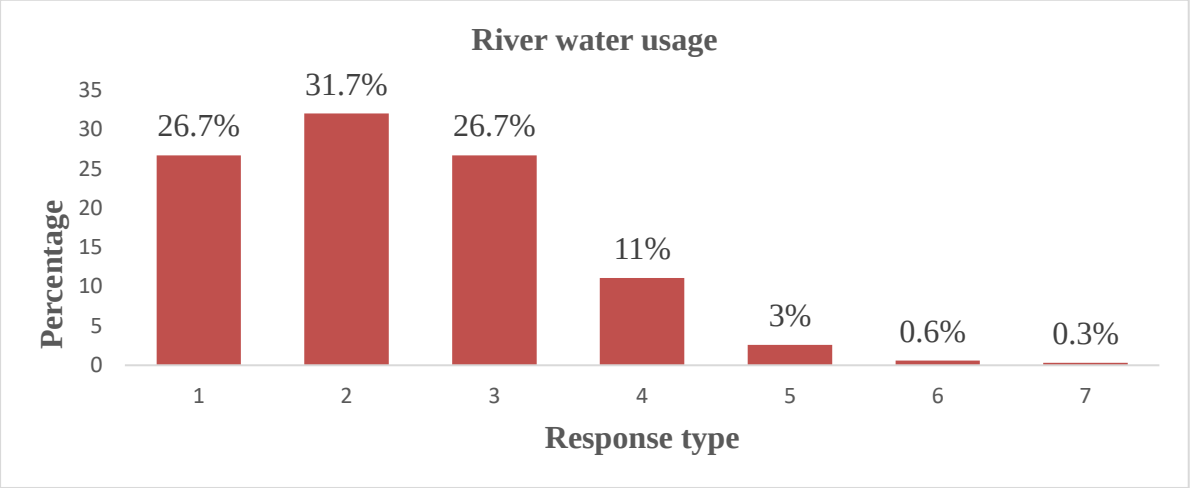

Figure 1: Practice of R. Chania raw river water usage

Key: Utility of river water

1. Use river water twice in a week, 91 food vendors
2. Use river water daily, 108 food vendors
3. Use both river water and Municipal metered water interchangeably, 91 food vendors
4. Use river water when Municipal water is unavailable/Meter is disconnected, 38 vendors
5. Use river water for cleaning and washing only but not for drinking, 10 vendors
6. Buy water from safe source (Municipal metered water), 2 vendors
7. Did not disclose their source of water, 1 vendor

As displayed on Table 2, the respondents' knowledge on raw river water safety shows that more than half 52% had reasonably good knowledge on river water safety on the use of IFAS supplementation. The rest, 42.5% were categorized as having poor knowledge on river water safety for domestic use of IFAS supplementation, Table 2.

Table 2: Knowledge on general safety of raw river water usage for food preparation

Knowledge Items	Proportion (n)	Percentage (%)
Poor Knowledge on water safety	162	47.5
Good Knowledge on water safety	179	52.5
Total (N)	341	100

The food vendors responses on the type of River Chania water contaminants is that 264 (77%), believed that general rubbish attributed to river water contamination, and only 2 (1%) responded that the agricultural pesticide use contributed to R. Chania water contamination. None of the 341 recorded responses associated Phenolic ecotoxins as R. Chania water contaminants, (Table 3).

Table 3 Knowledge on types of river water contaminants

Knowledge Items	Proportion(n)	Percentage (%)
Industry waste	13	4
General rubbish	264	77
Phenolic ecotoxin	0	0
Human body waste	62	18
Agricultural Pesticide	2	1
Total (N)	341	100

Responses from the food vendors knowledge on body harm or body ill-health as a consequence from using R. Chania raw water, indicated that 240 (70.4%), did not associate raw river water use with any body harm, hazard or illness, while 101 (29.6%) believed that there was harm in using raw water directly from R. Chania, (Table 4).

Table 4: Knowledge on body harm from raw river water usage

Body harm from raw river water usage	Proportion (n)	Percent (%)
Yes	101	29.6
No	240	70.4
Total	341	100

The association of the knowledge on safety of raw river water utility was established with the socio-demographic characteristics using a cross-tabulation model. The association of knowledge on the safety of raw river water utility and the education level parameter displayed a significantly associated correlation, $P<0.002$, $\chi^2 = 15.15$, df, 3, (Table 5).

Table 5: Cross-tabulation of knowledge on general safety of raw river water usage and socio-demographic characteristics

Characteristics	Knowledge of safety of raw river water usage		χ^2 (df)	P-value
Age	**No**	**Yes**		
<18	4(25%)	12(75%)		
18-22	31(31.3)	68(68.7%)		
23-27	34(31.2%)	75(68.8%)	2.183(5)	0.823
28-32	20(24.1%)	63(75.9%)		
33-37	10(35.7%)	18(64.3%)		
38-42	2(33.3%)	4(66.7%)		
Marital status	**No**	**Yes**		
Married	5 (6.9)	68 (93.1)		
Single	121 (93)	9 (7)	3.112 (3)	0.526
Divorced/Separated	134 (97)	4 (3)		
Gender	**No**	**Yes**		
Male	92 (91)	9 (9)	3.541 (4)	0.752
Female	29 (12)	211 (88)		
Level of Education	**No**	**Yes**		
None	4(80%)	1(20%)		
Primary	33(35.9%)	59(64.1%)	15.15(3)	**0.002**
Secondary	56(30.3%)	129(69.7%)		
Tertiary	8(13.6%)	51(86.4%)		
Employment status	**No**	**Yes**		
Not employed	83(31.6%)	180(68.4%)	2.160(1)	0.15
Employed	18(23.1%)	60(76.9%)		
Type of operated business	**No**	**Yes**		
Married	75(29.2%)	182(70.8%)		
Single	25(31.6%)	54(68.4%)	0.401(2)	0.818
Divorced	1(20%)	4(80%)		
Religion	**No**	**Yes**		
Islam	15(28.8%)	37(71.2%)		
Christianity	81(29.5%)	194(70.5%)	0.268(2)	0.875
Other	5(35.7%)	9(64.3%)		

Significant P<0.05

The association between the knowledge on safety of raw river water utility and the knowledge on body harm from raw river water usage was examined. The Bivariate cross tabulation of knowledge on general safety of raw river water usage is directly and significantly associated with knowledge on body harm from raw river water usage, χ^2; *df* (22.6, 1), N=341and *P=0.001*, (Table 6).

Table 6: Cross tabulation analysis of knowledge on general safety of raw river water usage and knowledge on body harm from raw river water usage

Variable in the Equation	Knowledge on body harm from river water usage		χ2(df)	AOR	95% C.I. for EXP (β)		P-value
					Lower	Upper	
Knowledge on safety of river water usage	**YES**	**NO**					
Poor Knowledge	68(42%)	94(58%)	22.6(1)	3.201	1.961	5.224	0.001*
Good Knowledge	33(18.4%)	146(81.6%)					

Significant P<0.05

Multivariate logistic regression model was used in determining specific association of Knowledge on Phenolic ecotoxin (applied as the dependent variable), while the Independent variable characteristic was good knowledge on safety of river water (also as predictor). Poor knowledge on safety of river water was entered as the reference in the model. Confounding effects in the model were controlled. The degree of association differences (β coefficient), and adjusted odds ratio, (AOR) and the probability, (P) value, indicated the magnitude of predictor risk, Table 7.

The model analysis illustrates that the level of secondary level education (2^0), A.O.R=3.331, (CI 2.019-5.496) *P=0.0001*, poor knowledge of river water safety, A.O.R=3.358, (CI 2.031-5.552) *P*=0.001 and practice of the utility of raw river water A.O.R=2.886, (CI 1.317-2.701) were significant predictors of knowledge of Phenolic ecotoxin water contaminant among the respondents' of the study, Table 7.

Table 7: Multivariate logistic regression analysis on knowledge on Phenolic ecotoxin and knowledge on safety of river water

Variable in the Equation	Knowledge on Phenolic ecotoxin			
	Sig. (*P*)	Exp. (β)	95% C.I. for EXP (β)	
			Lower	Upper
Poor Knowledge on River water safety	**0.001**	3.358	2.031	5.552
Age	0.989	1.002	0.793	1.265
Operated business type	0.99	0.997	0.586	1.695
Knowledge on river water contaminants	0.001	0.896	1.298	2.768
Employment status	0.537	0.259	0.606	2.617
Marital status	0.433	0.817	0.492	1.355
Secondary level of education (2^0)	**0.001**	3.331	2.019	5.496
Practice and usage of raw river water	**0.001**	2.886	1.317	2.701

Significant P<0.05

Discussion

The age analysis data of road side food vendors in this study, Table 1, reveals that most were below 32 years, with the largest proportion of vendors being in the age bracket ranging from 23-27 years 109, (32%), and 28-32 years 83, (24%).This is in line with the expected age range in a normal population of productive age in Kenya, according to data on the labour force statistics [9]Data also reveals that there were youthful vendors of 18-22 years, 99 (29%) and also minor-aged food vendors 16 (4.7%) having ages below the legal working age limit of 18 years. This revelation of a reasonably high number of youthful food vendors suggests that lack of opportunity in furthering education at the post primary, 1^0 and secondary, 2^0 level education in the adolescent phase period (13-19 years of age), may be instigating youthful persons to engage in unskilled socio-economic activities, such as road side and street food hawking, to fend for their livelihoods. This notion is further supported by the study's data showing that despite having attained the appropriate post-secondary age for attending further education in skill or specialist training at tertiary level, 3^0, only a small proportion of food vendors, 59 (17%) had tertiary education while the majority,185 (54.3%) had secondary school education.

A total of 263 (77%) responded that they had never been employed. This suggests that with limited prospects of income generation from formal employment engagement, most opted to venture into roadside food hawking business to self-sustain themselves. Most of the food items that were sold, Table 1, included ready to eat on-the-go snacks like boiled eggs, smokies/sausages, boiled maize that were sold by the majority vendors, 257(75%), while 79 (23%) engaged in selling sliced fruit pieces of pineapple and melon fruit.

Data analysis from this survey outcomes, illustrate that for the practice of river water usage required in their business operations, Figure 1, reveals that at least 108 food vendors (31.7%) use river water for food hygiene and preparation, while 91 (26.7%), use both river water and metered municipal water interchangeably. The practice of river water usage for food hygiene and food preparation, demonstrates that a notable proportion of food vendors are exposing themselves and the consumers of their food products to the threat of body ill-health from using raw river water. It can be inferred from the results tabulated in Figure 1that food vendors use river water because the rivers water is readily available from R. Chania, whose course and path flows in close proximity to sites where the food vendors have set up their business operations. Additionally, R. Chania water is readily available and accessible along the sampled sites, where the food vendors have set up temporary food stalls. The sites along the river bank where the food vendors can access river water are not restricted hence are easily accessible for river water harvesting.

The use of river water is crucial for the food preparation activities like washing of the food products, boiling and steaming of food during its preparation for sale. It is believed they do so, in a bid to cut down or reduce their business operational costs, as they will not utilize high capital or incur high expenses, in their food vending/hawking business set up and operations. Further, interpretation of the data is that food vendors use raw river water so as to minimize

their expenses and maintain their business operations with minimal expenditure impact. It can also be implied that some food vendors use raw river water supply not only for their food preparation activities, but additionally they exploit and diversify their economic activities from the easily available natural resource, by acting as water suppliers and benefit commercially by selling river water in plastic water drums and containers to their fellow food vendors. It is believed that some food vendors prefer not to pay for metered water services as it is cost-effective for them to use river water, as it is hassle-free, doesn't require expensive piping and tap installation expenses and furthermore there is no extra cost for recurring water meter charges or water tax imposition. It is thought that food vendors also prefer to use river water as it has the added advantage of reduced stress of paying for water disconnection and reconnection charges. The practice of raw river water usage for drinking and domestic purpose is reflected in other countries such as in Bangladesh, [10] and other low-income countries [11].

From the analyzed data in Table 2,a proportion of 179 (52 %) food vendors responded on having good and sufficient knowledge on the general river water safety for food preparation, while 162 (48%), had poor knowledge on the general river water safety for food preparation. Responses on the knowledge on whether the utility of raw river may cause body harm, Table 4, reveals that 240 (70%) vendors responded that nil body harm or ill health results from using raw river water while 101, (30%) believed that raw river water usage does cause ill health or body harm. This disclosure can be explained from the view that, a substantial proportion of vendors seem to have little exposure to education opportunities hence reduced reasoning capacity judging from data on their education level for a majority of the food vendors that was185 (54%) vendors having Secondary level education, 92 (27%) having primary level education and 5 (1.5%) having not attended any schooling, and only 59 (17%) having attained tertiary level education, Table 1. Additionally, low level schooling exposure does contribute in a lowered capacity to rationalize reason or base a deliberation or circumstance factually. Further to this argument, the association of knowledge on the safety of raw river water utility and the education level parameter displayed a significantly associated correlation between education level, and knowledge on the safety of raw river water usage, $P<0.002$, $\chi^2 = 15.15$, df, 3. Table 5.

Moreover, the food vendors knowledge on safety of raw river water usage was cross tabulated with knowledge on body harm or resultant ill-health from the usage of raw river water usage, Table 6. A strongly associated correlation ($P<0.001$, χ^2; df (22.6, 1), further augments the disclosure that poor knowledge on raw river water safety has a consequence on body harm or ill-health related condition, occasioned from using raw river water Table 6. Similarly, Rahman et al, [4]in their study reveal that having inadequate knowledge of raw river water utility for domestic use including drinking and food preparation, may have a negative impact resulting to a water borne related disease. Associated with that again, Anku et al, [12] document that chronic exposure to Phenol poisons in untreated consumed water results to increased human morbidity and low productive life quality. Phenolic compounds

inhibit oxidative phosphorylation, stimulate glycolysis, change the cell morphology and oxidize haemoglobin that provokes haemolysis of the red cell, according to Bukowska et al., [13].

The parameters of secondary level (2^0) of education, poor knowledge of river water safety and the practice of usage of raw river water were significantly associated with the knowledge of Phenolic ecotoxin contaminant, Table 7. The evaluation of this finding implies that the characteristic of poor knowledge of river water safety, is three-fold associated with the knowledge of Phenolic ecotoxin occurrence, hence a likely hood that having poor knowledge of river water safety is detrimental to an individual and has the probable risk to Phenolic ecotoxin exposure. Similarly, the practice of the usage of raw river water usage for food hygiene and food preparation, was three times significantly linked to Phenolic ecotoxin knowledge, hence can be interpreted to suggest that the usage and frequency of raw river water for food preparation activity will likely result to the risk of Phenolic ecotoxin contact in the body from food products washed or cooked in Phenolic ecotoxin contaminated water. The parameter of secondary (2^0) level of education was twice associated with Phenolic ecotoxin knowledge, hence revealing that having at least attained a secondary or below secondary level education, is likely to lead to the risk of exposing oneself to Phenolic ecotoxin exposure. Analogous to this result, Kasyoka et al, state in their study that low education levels is associated with the identification of water quality changes in River Chania[14].

Conclusion

Community sensitization and edification on harmful environmental compounds such as the occurrence of Phenolic ecotoxins in raw river water needs to be upscaled. To this end, the need of intensifying the knowledge of raw river water safety utility by stepping up the sensitization and awareness should be done enmass through community campaigns and road show drives. Street food hawkers and vendors should be encouraged to use metered tap water that has been purified and certified for public usage. The gaps for further research and innovation include the need to develop, design and implement or install portable water decontamination units along the fringes of river bank sites, especially in areas where semi-formal community economic activities involving food preparation is highly practiced.

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