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Estimation of Organophosphorus pesticide residue in cabbage in local market of South Bengaluru by QuEChERS method

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ABSTRACT

With their general use and associated health hazards, an examination was carried out to determine the occurrence of organophosphorus pesticide malathion in leafy vegetables, cabbage from local markets in South Bengaluru. Such pesticides are generally known to be among the most dangerous due to their extensive application, stability, specific toxicity, and bioaccumulation potential. Cabbage acts as important vectors of human exposure to these chemicals, mainly by consumption. As such, the analysis was carried out using Gas Chromatography Tandem mass spectroscopy. (GC-MS/MS) and all the samples were positive for malathion which was in excess of maximum residue limit.

1. INTRODUCTION

Organophosphate (OP) pesticides remain significant in managing agricultural pests due to their potency and fast environmental degradation. Malathion is an OP insecticide that is among the most widely available chemical commodities applied in agriculture and public health, particularly in vector management and crop protection (ATSDR,2013). Although malathion is relatively less toxic to humans when compared with other organophosphates, its widespread application raises pertinent issues regarding environment degradation, neurotoxicity, and risk to other organisms (ATSDR,2013) (Chung & Hsiao,2023).

The major action of malathion is inhibiting the enzyme acetylcholinesterase (AChE), which results in the cholinergic system entering a state of overflow fibrosis and the neuromuscular junctions, shifting the neural signalling pathways into dysfunction (Chung & Hsiao,2023) (CDC, n.d.). In humans, acute exposure could result in ophthalmoplegia and coma symptoms, bronchoconstriction, salivation, bradycardia, and, in cases of extreme exposure, seizures, respiratory difficulty, or death (CDC, n.d.). Recurrent or near-fatal exposure has been associated with various psychiatric and peripheral nervous system conditions, particularly in occupational settings with repetitive exposure to malathion (Senanayake & Karalliedde, 1987). Delayed neurotoxic syndrome, including weakness, numbness, and unusual sensations, reportedly results from low concentrations of the chemical (Shaikh & Shaikh, 2015).

Electrophysiological investigations have revealed a definite impact of malathion and other OP compounds on longer motor neuron axons, indicating a potential neurodegenerative alteration owing to OP toxicity. These investigations confirm that such OPs cause increased neurodegeneration, here targeting stronger motor neurons. This observation points out that agricultural workers are placed under an even greater risk, requiring stricter safety thresholds for malathion.

Malathion also carries substantial ecological and behavioural threats, jeopardizing useful non-target insects. For example, research on malathion's acute toxicity to cabbage butterflies (*Pieris brassicae*) has shown extensive mortality during blooming periods, which causes the loss of prominent behavioural modifiers. Similarly, Inayatullah and Salim (2016) supported that Brevicoryne brassicae or cabbage aphid endured not only from malathion and dichlorvos exposure but also great reproductive suppression, which can endanger breeding and nurturance resources. As pests are further disturbing fragile ecosystems, malathion can compromise integrated pest management (IPM) schemes through destabilizing multi-species ecological systems.

As with increasing issues related to residue build-up in edible agricultural crops, analysis techniques like the QuEChERS method—rapid, easy, cheap, effective, rugged, and safe—are invaluable for pesticide residue determination and food safety monitoring (Sigma-Aldrich, n.d.). The ease and sensitivity of the QuEChERS technique make it a powerful technique for quantifying malathion residues in complex food matrices. Regulatory agencies have embraced frameworks that apply such techniques for monitoring maximum residue limits (MRLs) to ensure public health security and inform agricultural practices.

Moreover, malathion is frequently promoted in a manner that trivializes its risks but maximizes its efficiency. Such grassroots-level promotion can mislead the public, making it necessary to adopt efficient policy mechanisms and risk communication strategies. Public health and environmental agencies must evaluate the evidence critically and adopt suitable communication strategies to facilitate safe use and risk awareness.

In conclusion, although malathion is still a significant agent for vector and pest control, it has toxicological issues for both human and environmental exposures. The neurochemical impact from exposure, specifically concerning AChE inhibition, ecotoxicological impact on non-target organisms, residue data, and regulatory concerns require a multidisciplinary, evidence-guided response to pesticide safety (Chuang & Hsiao, 2023) (CDC, n.d.) (Senanayake & Karalliedde, 1987) (Shaikh & Shaikh, 2015) (Inayatullah & Salim, 2016) (Sigma-Aldrich, n.d.). This study seeks to describe malathion's toxic mechanisms, its impact on invertebrate populations, and the applicability of residue detection methods to provide a complete review of its health and environmental effects.

2. METHODOLOGY

2.1 STUDY AREA

For several reasons, South Bengaluru is an excellent location to study organophosphate residues in cabbage. Cabbage is a vegetable that is cultivated on a large scale across Karnataka's districts. Previous research has indicated that farmers in regions like South Bangalore largely rely on chemical insecticides, particularly organophosphates, to manage infestations by pests in cabbage farming (Bheemappa., Naik & Shwethashree, 2020). The region selected for research was South Bangalore local markets, encompassing locations such as BTM Layout, Koramangala, Electronic City, JP Nagar, Bannerghatta Road, and Madiwala. In addition, highlighting its significance and appropriateness as a site for organophosphate residue research, previous academic research and theses on pesticide residues and soil-plant relations have been documented in the region (Krishikosh, 2019).

Fig: - Sample collected from BTM, 2nd Stage

Fig: - Sample collected from Madiwala

Fig: - Sample collected from Bannerghatta road

Fig: - Sample collected from JP Nagar, 7th Phase

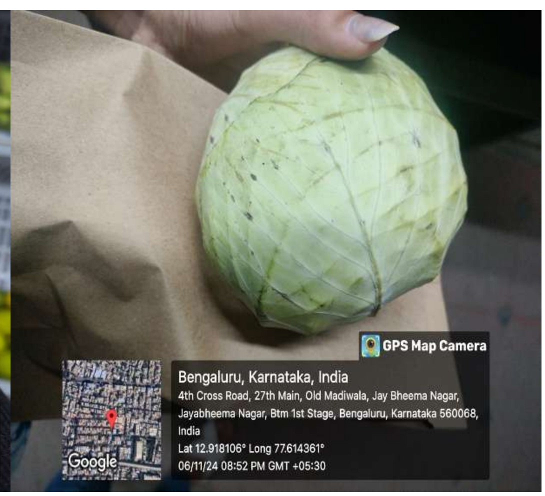


Fig: - Sample collected from Electronic city

Fig: - Sample collected from near Kormangala

Simple random sampling was employed to collect samples, the only criterion of inclusion being the presence of cabbage from the local market at south Bangalore, which is largely palatable, occupies less space, and possesses a fairly simple matrix. Infected and rotten cabbages were not considered.

3.2 EXTRACTION

QuEChERS, which stands for Quick, Easy, Cheap, Effective, Rugged, and Safe, is a general sample preparation method that was originally meant to analyze pesticide residues in fruits and vegetables. It has then been adapted to fit various purposes in environmental analysis and food safety testing due to it being simple to utilize and affordable. The QuEChERS extraction process begins with the addition of a minor amount of a pre-prepared sample in a tube, after which an organic solvent is added to extract the desired compounds. The combination is well shaken to allow for dissolution of the compounds within the liquid phase. A blend of salts is afterwards added to divide the layers and provide improved extraction effectiveness. After shaking and centrifugation to remove the solution, an amount of the fluid is piped into another tube containing cleanup agents that remove impurities. The last extract is now ready for analytical work employing appropriate laboratory equipment (QuEChERS, n.d.).

3.4 INSTRUMENTAL ANALYSIS

Gas Chromatography-Tandem Mass Spectrometry (GC-MS/MS) is a very sensitive analytical method that marries the power of separation by gas chromatography with the detection specificity of tandem mass spectrometry. This technique allows for the accurate identification and quantitation of target compounds in complicated mixtures by distinguishing analytes through their volatility, followed by mass-based determination via multiple fragmentation stages. GC-MS/MS is highly utilized in disciplines including environmental analysis, pharmaceutical screening, and forensic testing due to its capacity to provide qualitative as well as quantitative information regarding molecular structure (EAG Laboratories, n.d.).

4.RESULT AND DISCUSSION

A total of six cabbage samples were procured from different local markets in South Bengaluru and analysed for the presence of Malathion residues using Gas Chromatography–Tandem Mass Spectrometry (GC-MS/MS). The quantified Malathion content in each sample is presented below:

Table 1:

Sample Location	Malathion Residue (mg/kg)
Sample 1 — BTM Layout	11.260
Sample 2 — Koramangala	1.640
Sample 3 — Bannerghatta Road	1.880
Sample 4 —Electronic City	0.980
Sample 5 — Madiwala	11.270
Sample 6 — JP Nagar	5.240

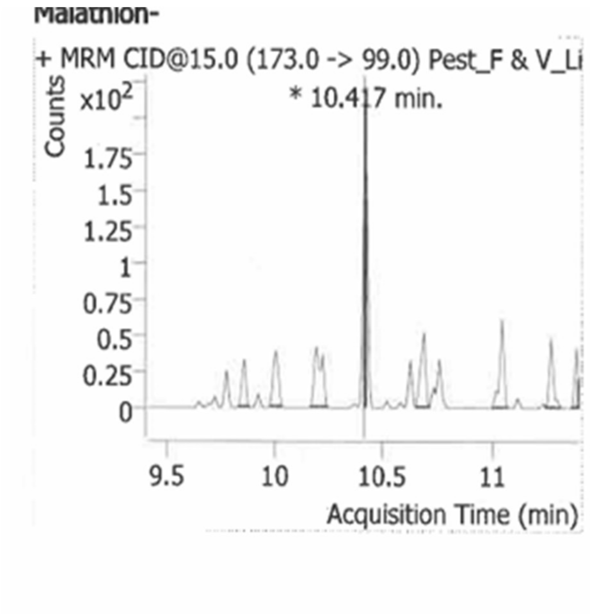
Fig: - Table showing sample collection location and concentration of Malathion in the respective areas.

The results clearly indicate that malathion residues were detected in all the cabbage samples analysed. Notably, the highest concentrations were recorded in Sample 1 from **BTM Layout (11.260 mg/kg)** and Sample 5 from **Madiwala (11.270 mg/kg)**. These levels considerably exceed the **Maximum Residue Limit (MRL)** for malathion in cabbage as recommended by international food safety authorities, which typically ranges around **0.5 mg/kg** (FAO/WHO, 2023).

Other areas such as **JP Nagar (5.240 mg/kg)** also showed elevated residue levels, while **Koramangala (1.640 mg/kg)**, **Bannerghatta Road (1.880 mg/kg)**, and **Electronic City (0.980 mg/kg)** samples exhibited comparatively lower, yet still concerning, malathion content.

Even though areas like JP Nagar, Koramangala, Bannerghatta Road, Electronic city, shows lower concentration of Malathion in sample but it can still be harmful on chronic consumption. It should be noted that the sample used for analysis was only 15g which is much less in quantity consumed by humans in a single meal, which makes this lower concentration equally dangerous.

Sample 1: BTM Layout



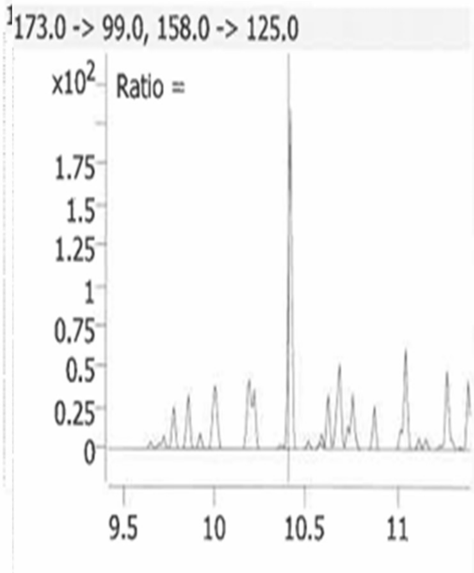


Fig: - Standard GC for Malathion

Fig: - Sample 1 GC for Malathion

The standard sample was run under specific gas chromatographic conditions and the retention time for standard time was found to be 10.417 mins. Even the sample run under the same chromatographic condition showed retention time if 10.417 mins.

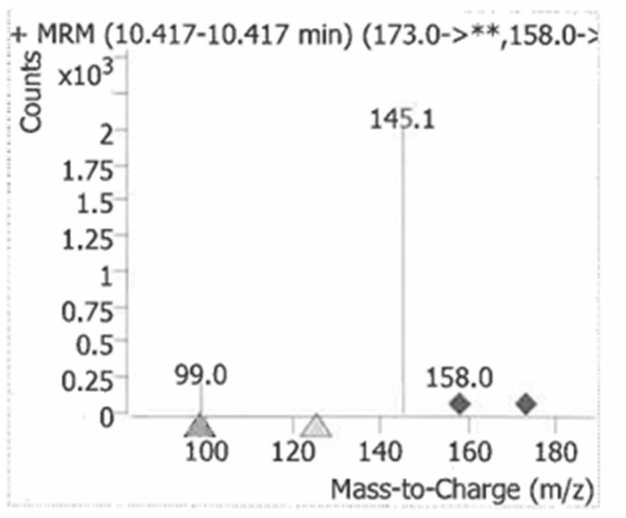
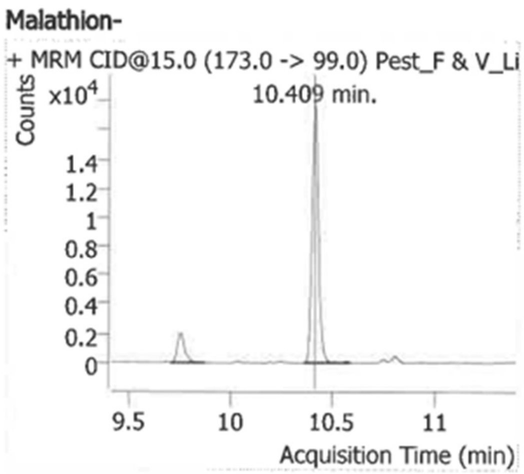


Fig: -Tandem Mass spectra of sample 1

Tandem mass spectrometry (MS/MS) analysis for the sample was done using multiple reaction monitoring (MRM) technique and fragments of m/z 99, 145, 158 were observed. These daughter or product fragments are specific for malathion molecules were seen in the spectra above.

Sample 2: Koramangala



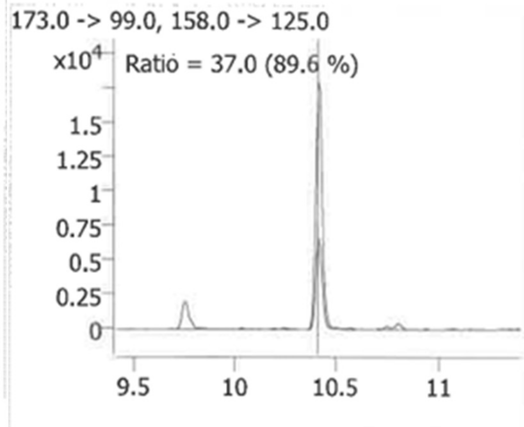


Fig: -Standard GC for Malathion Fig: -Sample 2 GC for Malathion

The standard sample was run under specific gas chromatographic conditions and the retention time for standard time was found to be 10.409 mins. Even the sample run under the same chromatographic condition showed retention time if 10.409 mins.

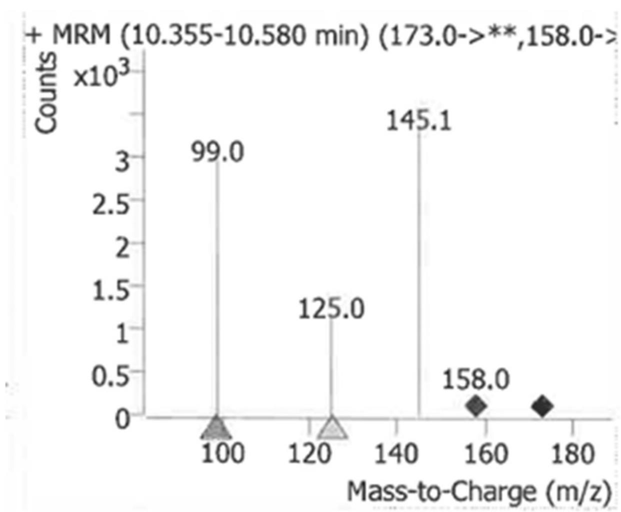
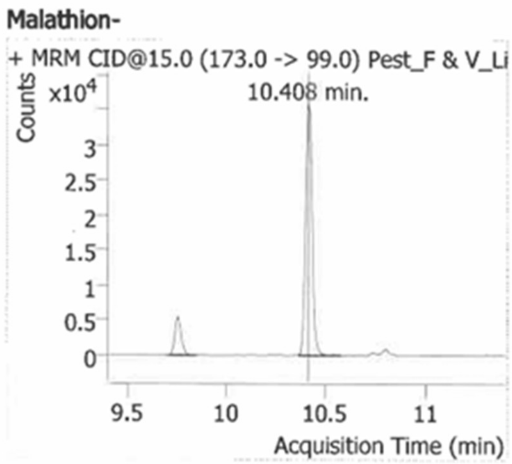


Fig: -Tandem Mass spectra of sample 2

Tandem mass spectrometry (MS/MS) analysis for the sample was done using multiple reaction monitoring (MRM) technique and fragments of m/z 99, 125,145.1, 158 were observed. These daughter or product fragments are specific for malathion molecules were seen in the spectra above.

Sample 3: Bannerghatta Road



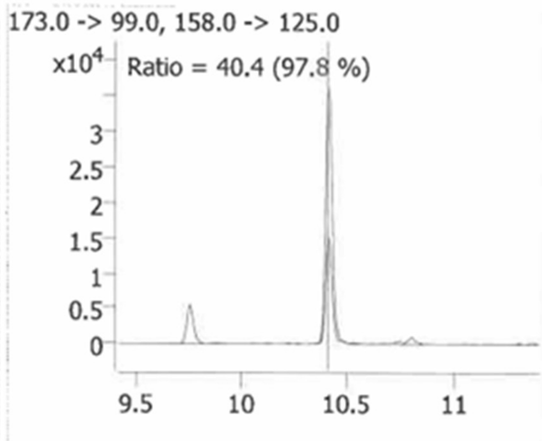


Fig: -Standard GC for Malathion Fig: - Sample 3 GC for Malathion

The standard sample was run under specific gas chromatographic conditions and the retention time for standard time was found to be 10.408 mins. Even the sample run under the same chromatographic condition showed retention time if 10.408 mins.

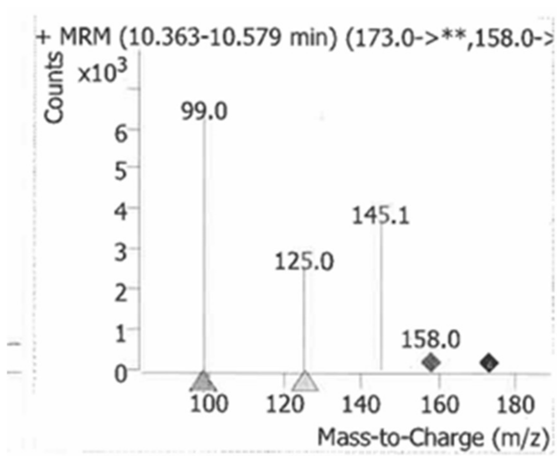


Fig: -Tandem Mass spectra of sample 3

Tandem mass spectrometry (MS/MS) analysis for the sample was done using multiple reaction monitoring (MRM) technique and fragments of m/z 99, 125,145.1, 158 were observed. These daughter or product fragments are specific for malathion molecules were seen in the spectra above.

Sample 4: Electronic city

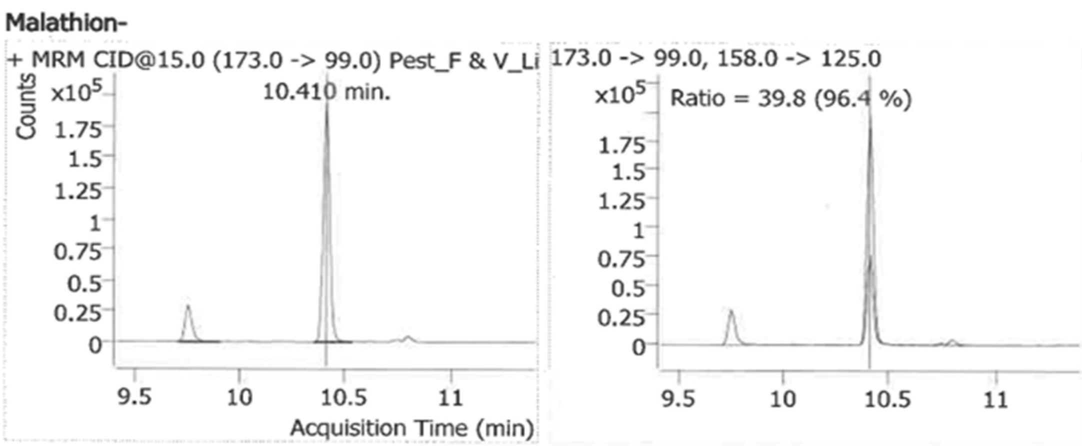


Fig: -Standard GC for Malathion Fig: - Sample 4 GC for Malathion

The standard sample was run under specific gas chromatographic conditions and the retention time for standard time was found to be 10.410 mins. Even the sample run under the same chromatographic condition showed retention time if 10.410 mins.

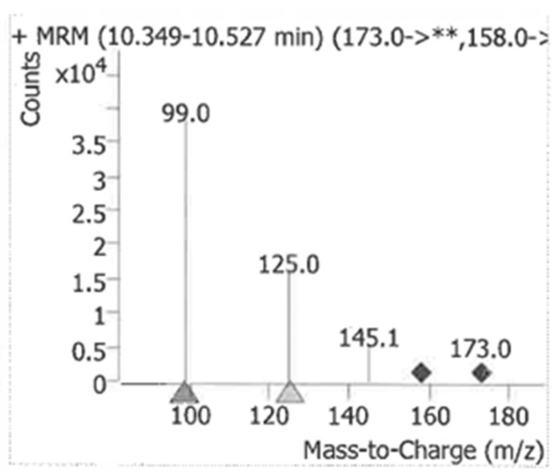
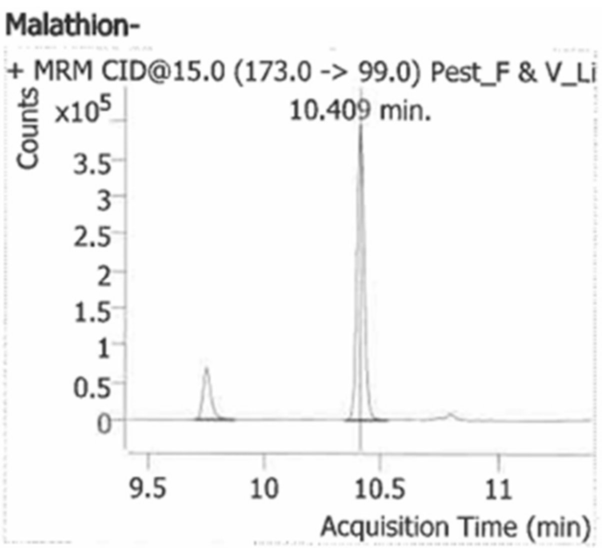


Fig: -Tandem Mass spectra of sample 4

Tandem mass spectrometry (MS/MS) analysis for the sample was done using multiple reaction monitoring (MRM) technique and fragments of m/z 99, 125,145.1, 173 were observed. These daughter or product fragments are specific for malathion molecules were seen in the spectra above.

Sample 5: Madiwala



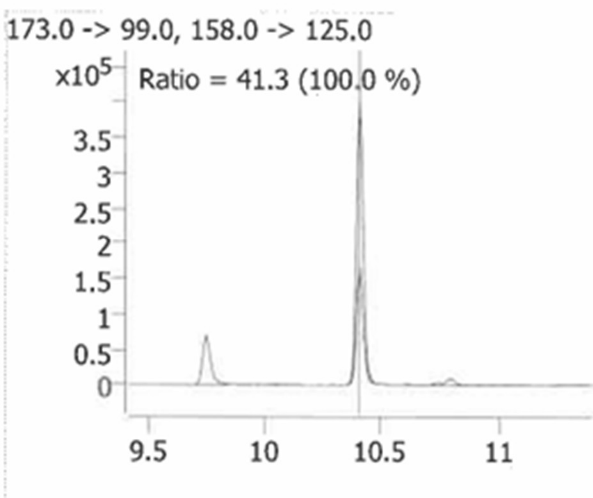


Fig: -Standard GC for Malathion Fig: -Sample 5 GC for Malathion

The standard sample was run under specific gas chromatographic conditions and the retention time for standard time was found to be 10.409 mins. Even the sample run under the same chromatographic condition showed retention time if 10.409 mins.

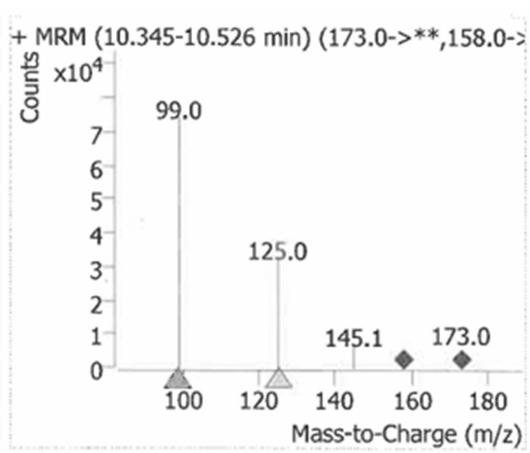


Fig: -Tandem Mass spectra of sample 5

Tandem mass spectrometry (MS/MS) analysis for the sample was done using multiple reaction monitoring (MRM) technique and fragments of m/z 99, 125,145.1, 173 were observed. These daughter or product fragments are specific for malathion molecules were seen in the spectra above.

Sample 6: JP Nagar

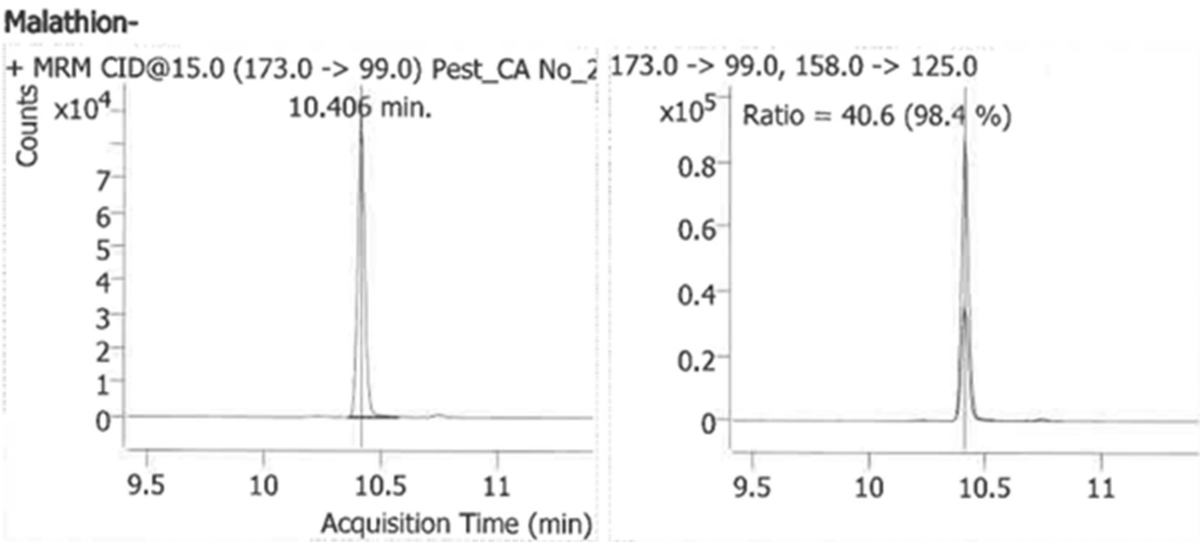


Fig: -Standard GC for Malathion Fig: -Sample 6 GC for Malathion

The standard sample was run under specific gas chromatographic conditions and the retention time for standard time was found to be 10.406 mins. Even the sample run under the same chromatographic condition showed retention time if 10.406 mins.

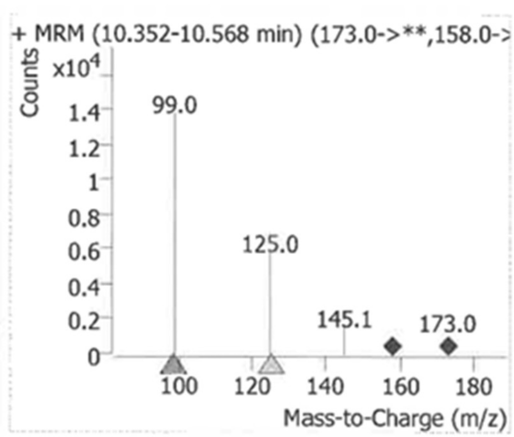


Fig: -Tandem Mass spectra of sample 6

Tandem mass spectrometry (MS/MS) analysis for the sample was done using multiple reaction monitoring (MRM) technique and fragments of m/z 99, 125,145.1, 173 were observed. These daughter or product fragments are specific for malathion molecules were seen in the spectra above.

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Authorship and Contributorship

- Author A: Methodology, Formal Analysis, writing- original draft, Data curation, Investigation, Project administration.
- Author B: Conceptualization, Supervision, Review.

Conflict of Interest

The author declares no conflict of interest.

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