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The Presence of Contaminants of Emerging Concern (CECs) and Volatile Organic Compounds (VOCs) in Northern Alabama Aquatic Ecosystems

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Abstract: Trace amounts of pharmaceuticals and other chemical compounds in drinking water are known to have adverse effects on human health, animal health, and the environment. This research study will show the presence of pharmaceuticals and other chemical compounds in Flint River (Madison County, AL) and Flint Creek (Morgan County, AL). Along the Flint River, samples were taken at three sites: Winchester Road, Brian Fork, and Hobbs Road. Similarly, along Flint Creek, samples were taken at three sites: Vaughn Bridge, Mean Bridge and Red Bank Bridge. At each site, samples were taken at four locations: upland from the water, along the banks of the water, at the deposition sediment of the water, and within the surface water itself. Samples were collected and analyzed for the presence of and concentration of chemical compounds by Waypoint Analytical Laboratory using proprietary High-Pressure LC/MS/MS (Liquid Chromatography and Dual Mass Spectroscopy) methods. Between 14 and 26 chemical compounds were identified at each site, adding up to a total of 548 chemical compounds between Flint River and Flint Creek. The chemical compounds and their concentrations were recorded and then sorted into four categories: pharmaceuticals and personal care products (PPCPs), VOCs (Volatile Organic Compounds), petroleum compounds, and CECs (Contaminants of Emerging Concern). Between both Flint River and Flint Creek, PPCPs were the largest category of contaminants, comprising of 46% of compounds identified. This study demonstrates that Flint River and Flint Creek are potentially hazardous to Madison County and Morgan County residents, as trace concentrations of pharmaceuticals in drinking water can cause several health issues.

Key words: PPCPs, VOCs, CECs, Flint Creek and Flint River, seasonal variations, STP (Sewage Treatment Plant).

1. Introduction

PPCPs (Pharmaceutical and Personal Care Products) have been detected in surface water, wastewater and drinking water [1-9]. The various level of removal of these CECs (Contaminants of Emerging Concerns) depends on the chemical, the operating conditions, and the treatment technologies [10-13]. Various methods of PPCPs removal through wastewater treatment plants have led to detection of these compounds in the aquatic environment, in the nanogram to microgram per liter (ng/L to μg/L) concentration range worldwide [14-23]. Research has shown that certain PPCPs may have an impact on the environment at the microgram to nanogram per liter concentrations with a range of potential impacts [24-31]. As with other pollutants, the extent and nature of the health effect will depend on many factors including level of exposure and length of time exposed.

Some immediate symptoms of exposure include respiratory tract irritation, headaches, dizziness, visual disorders and memory impairment.

Recent studies by environmental researchers, chemical industries, water utility companies, and local environmental agencies have discovered high

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concentrations of gasoline products in soils/sediments, ground water in many states in the U.S. due to leaking underground gasoline-storage-tanks, oil seeps, and petroleum spills. Frequent occurrence of low to intermediate concentrations of these products was discovered in some reservoirs used for public water supply [32]. Here in Northern Alabama, the problem is very severe but largely gone unnoticed. This study of two major watersheds (Flint Creek and Flint River) determined the occurrence and distribution of industrial pollutants in the Lower Tennessee River Basin's soil/sediment matrix.

Previous studies conducted at these watersheds evaluating the occurrence and risk of PPCPs have assessed a small number of PPCPs. A better understanding of the occurrence of PPCPs in large water systems, particularly in areas with substantial urban development such as Madison county, and rural area such as the Morgan county, needed further investigation. The purpose of this study was to assess the presence of PPCPs, VOCs (Volatile Organic Compounds), petroleum compounds and other CECs in Flint River and Flint Creek from varying proximities to a major effluent discharge site and to assess the risk potential to the environment (Fig. 1). PPCPs were measured in both surface water and sediment samples over the summer of 2018 and 2019. The sampling pattern was selected due to the prevailing southern current in this portion of the watersheds [33]. When possible, an RQ (Risk Quotient) was estimated to determine which compounds are at a level of concern based on existing effects data or models.

1.1 Flint River

The Flint River, 65.7 miles (105.7 km) long and 568 square miles (1,470 km^2), is a tributary to the Tennessee River (Fig. 2 Right). The river rises, and flows south into Madison County, Alabama, where most of the river's watershed is located. The river rises on the southwestern fringe of the Cumberland Escarpment and primarily drains the plains that have been created by the erosion of this fringe of the Appalachians.

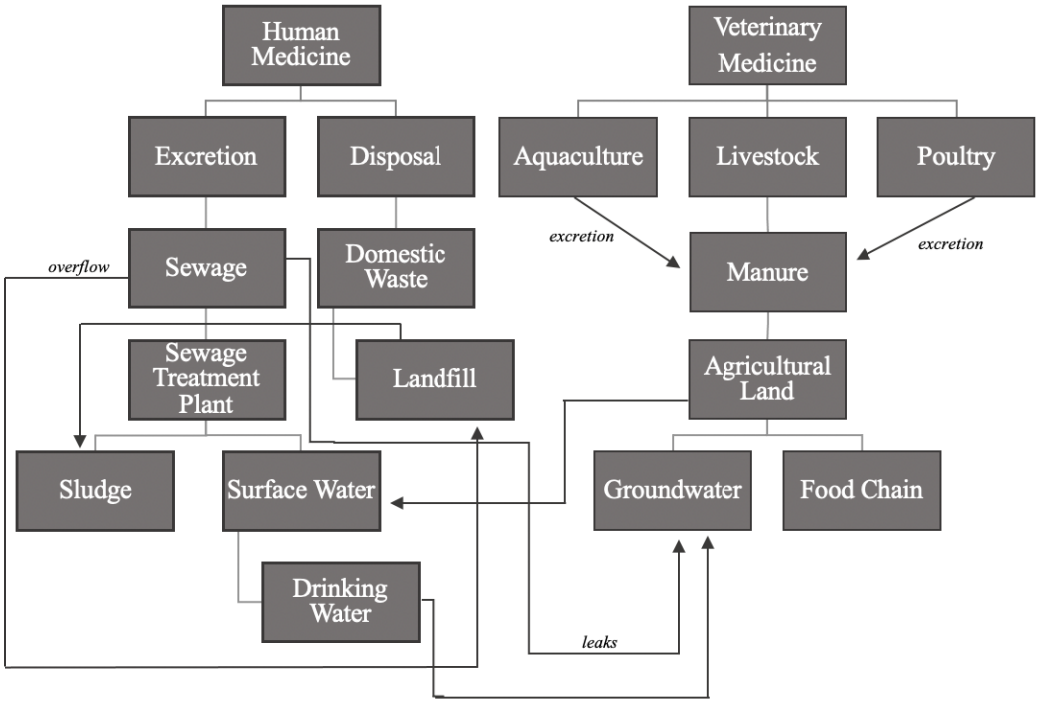

Fig. 1 Illustration of environmental contaminants sources of emerging concerns, VOCs and PPCPs. Source: N. Sheeley, and P. Okweye, April 2021.

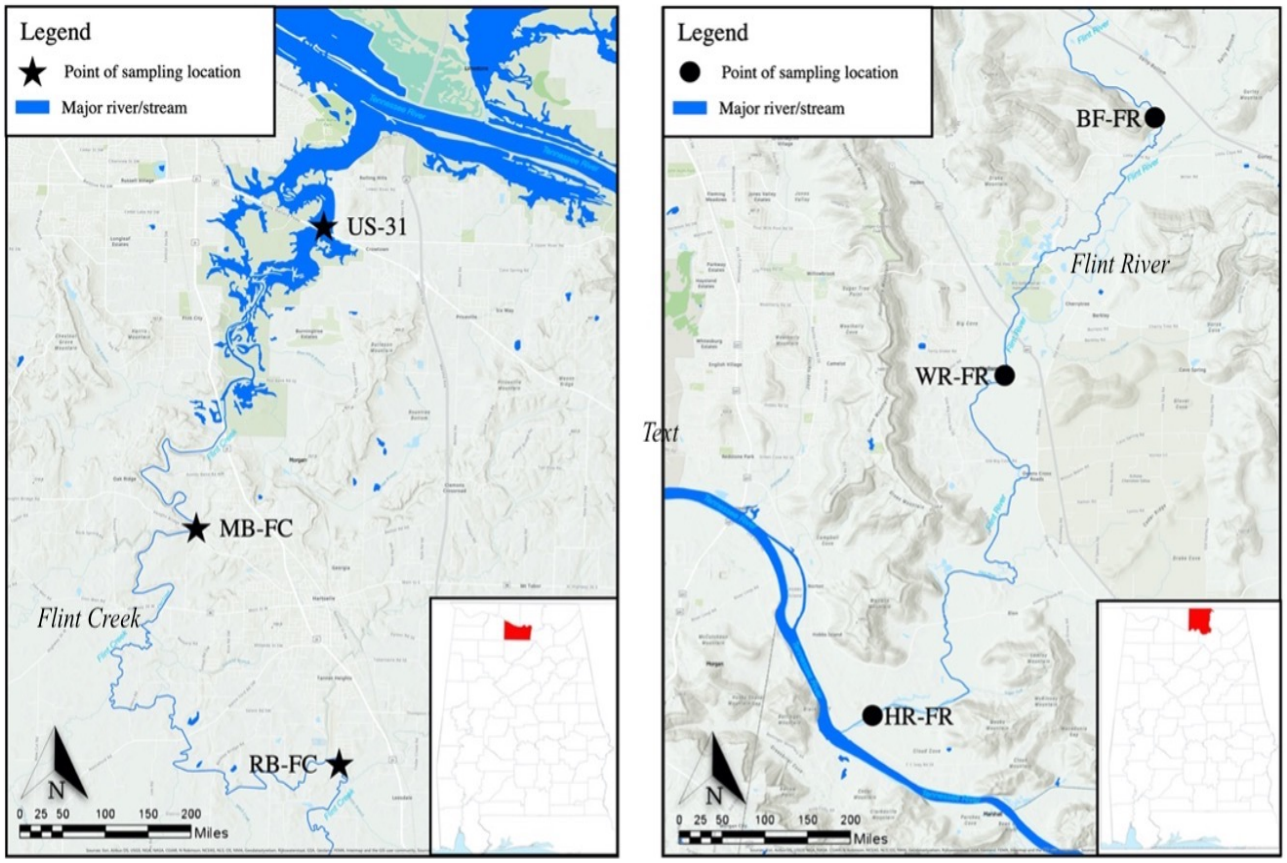

Fig. 2 Map of Flint Creek (Left) and Flint River (Right) watershed sites.

The land within this watershed is predominantly agricultural and has experienced significant recent residential growth from the city of Huntsville. Runoff from agricultural activities and urbanization contributed to organic enrichment and DO (Dissolved Oxygen) impairments in the lower mainstream of the Flint River in Alabama. Madison County, Alabama's estimated population is 361,811 with a growth rate of 1.36% in the past year according to the most recent United States census data. Madison County, Alabama, is the third largest county in Alabama.

1.2 Flint Creek

Flint Creek (Fig. 2 left) and its tributaries comprise 150 miles of streams draining 291,000 acres of land in Cullman, Lawrence, and Morgan counties of North Alabama. The water level of the lower course of the creek is greatly affected by the reservoir levels along the Tennessee River. The creek is utilized by many residents of North Alabama, and Central Tennessee Valley in the Decatur area.

2. Materials and Methods

2.1 Sites

Flint Creek and Flint River (Table 1) are two of Northern Alabama's largest watersheds. In order to get accurate surveys of their water and soil quality, samples at multiple sites and locations were taken. Each site varies in elevation and provides a different geographical perspective for each watershed. The Flint Creek watershed is located at 34°30′ north latitude, 86°57′ west longitude. The Flint River watershed is located at 34°30′ north latitude and 86°28′ west longitude (Okweye, et. al, 2007; Table 1). Three sampling sites per watershed were chosen to collect water samples (Fig. 2). Sites along Flint Creek watershed were Vaughn Bridge, Mean Bridge, and Red Bank Bridge on Red Bank Road. Red Bank Road,

Table 1 Sites for both watersheds and their codes.

Flint River (FR) Watershed (Huntsville, Alabama)				
Sites	Stream	Codes	Coordinate Points	Elevation
1	Winchester Road	WR-FR	34°30′12.5″ N 86°28′00.4″ W	721.5 ± 19"
2	Briar Fork Road	BF-FR	34°47′23.15″ N 86°29′05.4″ W	751.5 ± 36"
3	Hobbs Island Road	HR-FR	34°32′19.5″ N 86°55′52.6″ W	660.5 ± 30"
Flint Creek (FC) Watershed (Decatur, Hartselle, Alabama)				
Sites	Stream	Codes	Coordinate Points	Elevation
4	Red Bank Road	RB-FC	34°30′22.5″ N 86°57′20.8″ W	788.5 ± 50"
5	Means Bridge	MB-FC	34°29′37.8″ N 87°01′34.9″ W	602.5 ± 42"
6	Vaughn Bridge Road	VB-FC	34°27′48.15″ N 86°57′52.4″ W	521.5 ± 56"

which runs through Wheeler NWR (National Wild Refuge)-Dancy Bottoms Natural Trail, has an elevation of 788.5 ± 50″. Means Bridge, which is an intermediate site along Flint Creek, has an elevation of 602.5 ± 42″. Vaughn Bridge, which in addition to Flint Creek intersects with Snow Hill Branch and Goose Creek, has an elevation of 521.5 ± 56″. Sites along Flint River were Winchester Road, Briar Fork Road, and Hobbs Island Road. Winchester Road, which intersects with the smaller Charles Creek just before it intersects with Flint River, has an elevation of 721.5 ± 19″. Briar Fork, located at Huntsville's outer limits in Moore's Mill, AL near Kalea Park, has an elevation of 751.5 ± 36″. Hobbs Island Road, which intersects the Flint River near David Gumm Farm, Stavemill Hallow and Burr Hallow, has an elevation of 660.5 ± 30″.

2.2 Samples

At each site, four different samples were taken. The first sample was taken upland, away from the body of water. This sample serves as a control, demonstrating the quality of soil that does not directly interact with the water. The second sample was taken at the banks of the water, where the body of water meets land. The third sample was taken at the deposition sediment within the body of water (Table 2). Deposition sediment is a dome-like gathering of sediment in the middle of the river that forms from transportation of sediment from runoff and erosion. This is the most ideal location for surveying chemical compounds; it has the most diverse set of sediment (Okweye et al., 2013). The fourth sample was taken from the surface water (the running water itself). Upland, bank, and deposition samples were solids. Collected using small shovels and placed in containers for storing, concentrations of chemical compounds were measured in microgram per kilogram (μg/kg). The surface water samples were liquid. Collected using Baylors and placed in bottles for storing, concentrations of chemical compounds were measured in microgram per liter (μg/L). Samples were collected and analyzed for the presence of and concentration of chemical compounds by Waypoint Analytical using proprietary High Pressure LC/MS/MS (Liquid Chromatography and Dual Mass Spectroscopy) methods. High pressure

Table 2 Codes for chemical categories and samples.

Categories of Chemical Compounds at the Sites	CODE
a. Pharmaceutical and Personal Care Products	PPCPs
b. Volatile Organic Compounds	VOCs
c. Petroleum Compounds	PCs
d. Contaminants of Emerging Concern	CECs
Samples	CODE
a. Surface Water	SW
b. Depositional Sediment	Dep
c. River-Bank Sediment	Bk
d. Upland Sediment Samples	Up

liquid chromatography separates, identifies and quantifies each chemical compound in a solution or solid. It relies on pumps to pass a pressurized liquid solvent containing the sample mixture through a column filled with a solid adsorbent material. Dual mass spectroscopy, also referred to as tandem mass spectroscopy, utilizes two spectrometers to increase their ability to analyze the chemical components of a solution or solid. Between 14 and 26 chemical compounds were identified at each site, adding up to a total of 548 chemical compounds between Flint River and Flint Creek.

3. Results and Discussion

Between 14 and 26 contaminants were identified at each location, adding up to a total of 548 contaminants between both watersheds. Once all the contaminants were identified, their concentrations were recorded. Concentrations of contaminants at Deposition Sediment, Bank Site, and Upland Site were recorded in μg/kg. Concentrations of contaminants in surface water were recorded in μg/L. Then, the chemical composition of each contaminant was analyzed and placed in one of four categories based on their characteristics: PPCPs, VOCs, petroleum compounds, and CECs. PPCPs are defined as substances used for personal health or cosmetic reasons. VOCs include a variety of chemicals, some of which may have short- and long-term adverse health effects. Petroleum compound are defined as fuel or crude oil.

CECs are an all-inclusive category for contaminants that might not necessarily be "pollutants"—some happen naturally from anthropogenic activity. A small percentage of contaminants could not be identified by lab techniques, and were titled "Unknown". These compounds were placed in a separate "Unknown" category in distribution graphs (Figs. 6 and 7).

Fig. 1 shows the illustration of environmental contaminants sources and Fig. 7 shows the combined distribution of contaminants at Flint Creek and Flint River. By far, PPCPs are the largest category, comprising 56% of contaminants at the Flint Creek watershed. In second position are VOCs, which comprise of 30% of the distribution. CECs and petroleum compounds contribute smaller portions of the distribution, representing 8% and 6%, respectively. Fig. 6 shows the distribution of contaminants at Flint River. The distribution of compounds at Flint River is more uniform than that of Flint Creek. Still, PPCPs are the largest category, comprising 38% of the total distribution. CECs are second, comprising 22% of the distribution, followed by VOCs at 19%. Petroleum compounds comprise a comparatively large 16% of contaminants, while "Unknown" compounds were just 5% of the data. Fig. 7 shows the overall combined distribution of contaminants between both Flint Creek and Flint River. Predictably, PPCPs are the largest category, comprising 46% of the combined distribution. VOCs are second at 24%, followed by CECs at 16%, petroleum compounds at 11%, and "Unknown" compounds at 3%. Fig. 8. Shows concentrations of NSAIDs (Non-steroidal Anti-inflammatory Drugs) reported in surface water samples from different countries compared to the North Alabama Watersheds (ng/L).

Figs. 9-14 show the top five contaminants in terms of concentration at each location. PPCPs appeared made a total of 41 appearances in the top five, which is the most of all categories. The contaminant with the overall highest concentration was a PPCP at WR-FR in deposition sediment called 1,2,3,5,6,7,8,8-Naphthalene, with a concentration 2,382.1 μg/kg (Fig. 9). This is well over EPA (Environmental Protection Agency) Maximum Contaminant Levels for drinking water, surface water, ground water, municipal sewage, and agricultural soils. 1,2,3,5,6,7,8,8-Naphthalene has not appeared in literature or chemical compounds databases, but there is information in databases about a similar compound called 1,2,3,4,5,6,7,8-Octahydronaphthalene. This compound is very toxic and corrosive, and has been

linked to some antipsoriatics and treatments for joint disorders, arthritis. The highest amount of PPCPs and VOCs from one site was from HR-FR (Figs. 3 and 4). Interestingly, Hobbs Road on Flint River is the site of City of Huntsville Wastewater Collection and Treatment Centers. The collection system is a large network of more than 1,400 miles of underground sewer pipes, 35,000 manholes and 63 pumping stations.

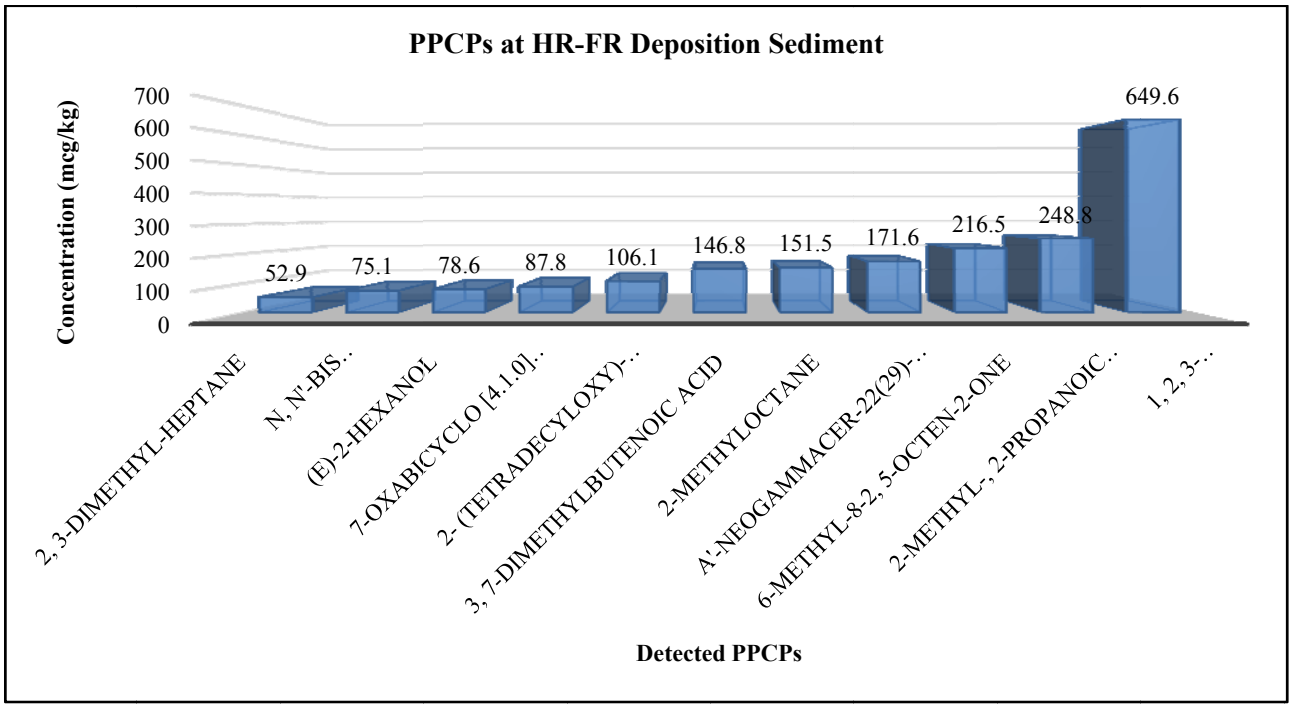

Fig. 3 PPCPs contaminants at the Hobbs Road Estuary of Flint River.

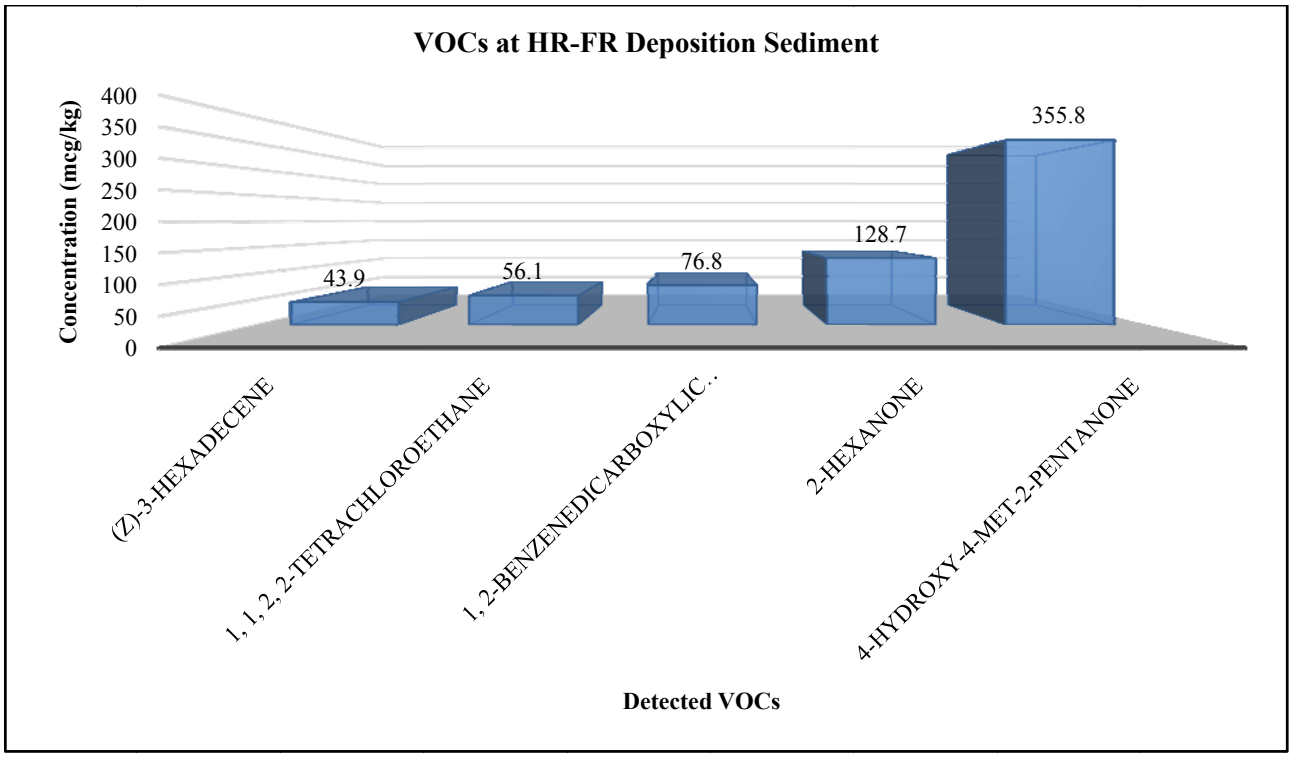

Fig. 4 VOCs contaminants at Hobbs Road Estuary of Flint River.

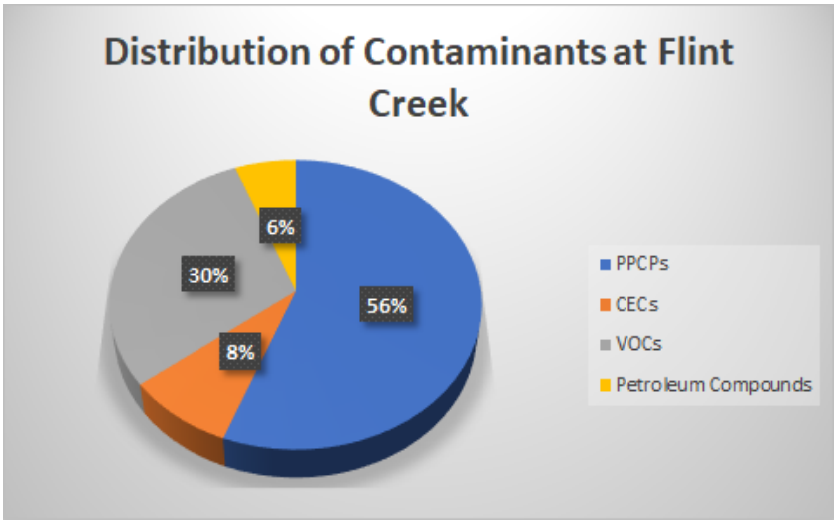

Fig. 5 Distribution of contaminants at Flint Creek.

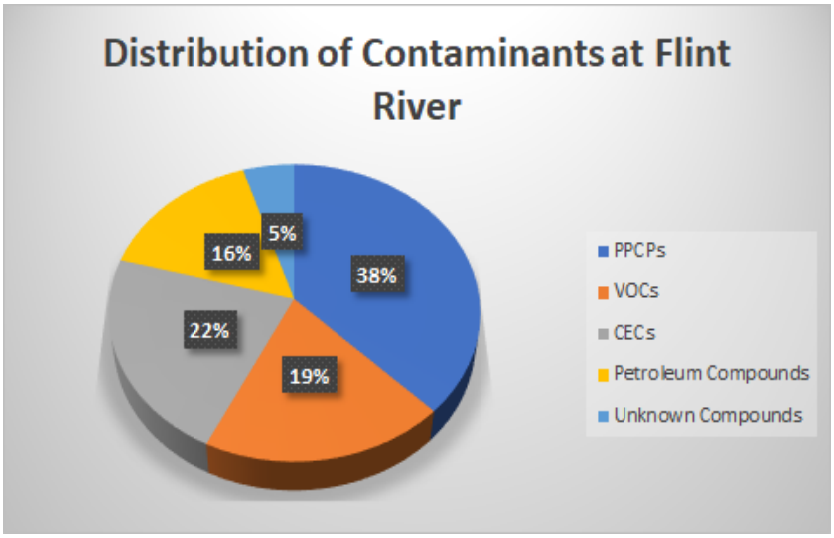

Fig. 6 Distribution of contaminants at Flint River.

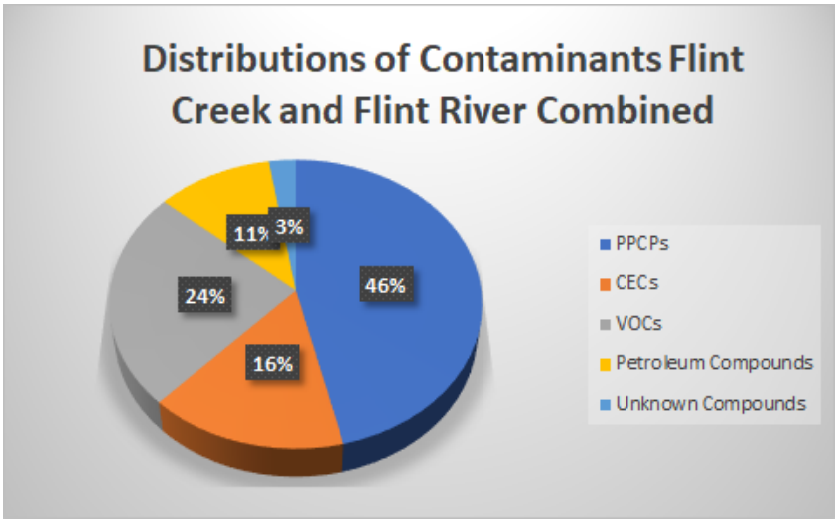

Fig. 7 Distribution of contaminants at Flint Creek and Flint River Watersheds combined.

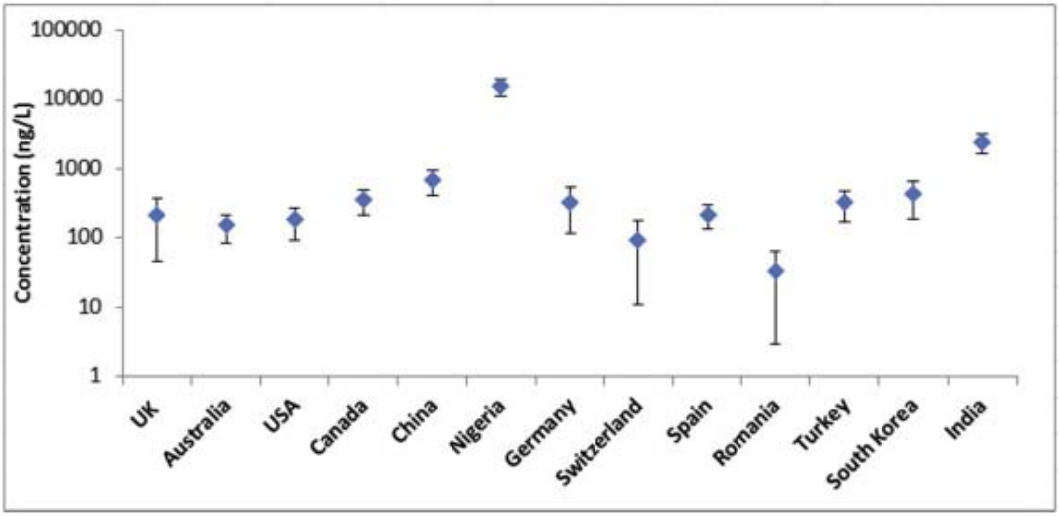

Fig. 8 Concentrations of NSAIDs (Non-steroidal Anti-inflammatory Drugs) reported in surface water samples from different countries compared to the North Alabama Watersheds (ng/L). Surface water (Concentrations in µg/L)/Dep. Sediment/Bk. Sediment/Up. Sediment (µg/kg) (Ebele, et al., Emerging Contaminants, 2017).

Flint River - WRFR #1: Winchester Road											
Dep-028A	Compounds	Conc.	Bk-029A	Compounds	Conc.	Up-030A	Compounds	Conc.	001A	Compounds	Conc.
PPCP	1, 2, 3, 5, 6, 7, 8, 8-NAPHTHALENE	2382.1	CEC	.GAMMA.-SITOSTEROL	1549.1	CEC	DECA-1H-CYCLOPROP [E] AZULENE	587.1	CEC	2, 3-DIHYDRO-3-METHYLFURAN	11.7
CEC	.GAMMA.-SITOSTEROL	970.5	PC	2, 5-DIMETHYLHEPTANE	341.5	PC	2, 5-DIMETHYLHEPTANE	389.2	PPCP	1, 1-DIMETHYLCYCLOHEXANE	7.5
CEC	HEXATRIACONTANE	644.9	CEC	22-DIEN-3-OL, ACE-ERGOSTA-14	321.4	CEC	CARYOPHYLLENE	326.8	VOC	(E)-2-NONENAL	6.2
CEC	HENEICOSANE	506.1	VOC	4-HYDROXY-4-MET-2-PENTANONE	308.4	VOC	4-HYDROXY-4-MET-2-PENTANONE	278.8	VOC	2, 2, 5, 5-TETRAMETHYL-3-HEXENE	6.1
PPCP	ALPH-1-NAPHTHALENEPROPANOL	455.1	PC	HEPTACOSANE	265.8	PC	2, 6-DIMETHYLHEPTANE	243.7	PPCP	2, 3, 4-TRIMETHYLPENTANE	4.9

Fig. 9 Top 5 compounds at WR-FR Deposition Sediment, Bank Site, Upland Site and SW.

Flint Creek- MBFC #5: Mean Bridge											
Dep-040A	Compounds	Conc	Bk-041A	Compounds	Conc	Up-042A	Compounds	Conc	005A	Compounds	Conc
PC	.BETA.-SITOSTEROL	1408.1	PPCP	.ALPH-1-NAPHTHALENEPROPANOL	688.9	VOC	23, 24-EPOXY-STIGMASTANE	654.6	PPCP	(E)-2-PENTENAL	17.9
PPCP	10-METHYLEICOSANE	1262.1	PPCP	2, 3,-DIMETHYL-2-NITROBUTANE	680.1	PPCP	2-CYCLOPROPANENONANOIC ACID	407.2	VOC	1-METHYL-2-PROP-CYCLOHEXANE	8.9
VOC	7-HEXYLTRIDECANE	1116.1	VOC	1, 2-BENZENEDICARBOXYLIC ACID	454.8	VOC	4-HYDROXY-4-MET-2-PENTANONE	241.1	PC	2, 4-DIMETHYL-1-HEPTENE	6.3
CEC	DECA-1H-CYCLOPROP [E] AZULENE	882.1	PPCP	4, 5-DIMETHYL-1-HEXENE	371.8	PPCP	4-ETHYL-1-HEXENE	237.7	CEC	PENTYL ESTHER BUTANOIC ACID	5.6
CEC	1H-CYCLOPENTA [A] PENTALEN-7-0	625.1	CEC	2, 3, 3-TRIMETHYLCYCLOHEXANONE	366.1	PPCP	7-OXABICYCLO [4.1.0] HEPTANE	232.2	PPCP	3, 5, 5-TRIMETHYL-2-HEXENE	4.5

Fig. 10 Top 5 compounds at MB-FC Deposition Site, Bank Site, Upland Site and SW.

Flint River- HRFR #3:Hobbs Road											
Dep-034A	Compounds	Conc	Bk-035A	Compounds	Conc	Up-036A	Compounds	Conc	003A	Compounds	Conc
PPCP	1, 2, 3-TRIMETHYLCYCLOHEXANE	649.6	VOC	7-METHANOAZULEN-5-OL-1H-3A	542.4	PC	2, 5-DIMETHYL-HEPTANE	292.5	CEC	3-METHYL-2-BUTENAL	20.5
CEC	(3E, 5E, 7E)-6-METHYL-8-(2, 6, 6)	632.4	VOC	1, 2-BENZENEDICARBOXYLIC ACID	320.4	VOC	4-HYDROXY-4-MET-2-PENTANONE	251.5	PPCP	1-METHYL-2-PROPCYCLOHEXANE	9.3
PC	2, 5-DIMETHYL-HEPTANE	365.8	CEC	.BETA.-SITOSTEROL	315.8	CEC	5, 6-TRIOL, ERGOST-25-ENE-3	246.6	PPCP	2, 2, 5, 5-TETRAMETHYL-3-HEXENE	7.4
VOC	4-HYDROXY-4-MET-2-PENTANONE	355.8	PC	2, 5-DIMETHYL-HEPTANE	280.9	PPCP	OCTACOSANE	228.5	CEC	4-ETHYL-1-HEXENE	6.8
PPCP	2-METHYL-, 2-PROPANOIC ACID	248.8	VOC	4-HYDROXY-4-MET-2-PENTANONE	246.1	PPCP	7-OXABICYCLO [4.1.0] HEPTANE	199.5	PPCP	2-BUTENAL	5.4

Fig. 11 Top 5 compounds at HR-FR Deposition Site, Bank Site, Upland Site and SW.

Flint Creek- VBFC #6: Vaughn Bridge											
Dep-043A	Compounds	Conc	Bk-044A	Compounds	Conc	Up-045A	Compounds	Conc	004A	Compounds	Conc
PC	.BETA.-SITOSTEROL	1126.1	CEC	4-ETHYL-1-HEXENE	331.7	CEC	.GAMMA.-SITOSTEROL	866.9	VOC	2, 3-DIHYDRO-4-METHYLFURAN	20.4
PPCP	4A, 4B, 3(4H)-PHENANTHRENONE	1048.1	VOC	4-HYDROXY-4-MET-2-PENTANONE	287.5	PPCP	2, 3-DIMETHYL-2-NITROBUTANE	631.8	PPCP	4, 5-DIMETHYLOXAZOLE	10.2
PPCP	2-NONADECANONE	881.4	PC	2, 5-DIMETHYLHEPTANE	274.7	PC	TRICYCLO [4.3.0.07, 9] NONANE	544.2	VOC	TRI (2-CHLOROETHYL) PHOSPHATE	8.3
PPCP	3, 3-DIMETHYL-1-PENTENE	417.8	PPCP	CYCLOPROP [7, 8] ERGOST-22-EN-3	262.9	CEC	3-PENTEN-2-OL	354.3	CEC	4-ETHYL-1-HEXENE	7.4
PPCP	2, 7-DIMETHYL-1, 8-NONADIENE	408.4	VOC	7-METHYLHEXACANE	242.1	VOC	4-HYDROXY-4-MET-2-PENTANONE	308.5	VOC	2-SEC-BUTYL-3-METHYL-1-PENTENE	7.1

Fig. 12 Top 5 compounds at VB-FC Deposition Site, Bank Site, Upland Site and SW.

Flint Creek- RBFC #4: Red Bank Bridge											
Dep-037A	Compounds	Conc	Bk-038A	Compounds	Conc	Up-039A	Compounds	Conc	004A	Compounds	Conc
PC	2, 5-DIMETHYL-HEPTANE	279.4	PC	2, 5-DIMETHYL-HEPTANE	210.8	PC	5-BUTHYL-6-HEXYLOC-1H-INDENE	790.7	CEC	3-METHYL-2-BUTENAL	18.6
VOC	4-HYDROXY-4-MET-2-PENTANONE	224.2	VOC	4-HYDROXY-4-MET-2-PENTANONE	194.3	PPCP	OCTAHYD-2 (1H) -NAPHTHALENE	764.6	PPCP	DIETHYL PHTHALATE	7.9
PC	2, 6-DIMETHYL-HEPTANE	176.7	VOC	2, 6, 11-TRIMETHYLDODECANE	110.2	VOC	EICOSANE	497.2	PPCP	1-METHYL-2-PROP-CYCLOHEXANE	7.1
UK	UNKNOWN	167.7	PC	2, 4-DIMETHYL-HEPTANE	101.7	PPCP	CYCLOPROPA [D] NAPHTHALEN-2-4A	325.3	VOC	1, 2, 5, 5-TETRAMETHYL-3-HEXENE	6.9
PPCP	(Z)-9-OCTADECENAMIDE	146.8	VOC	1, 1, 2, 2-TETRACHLOROETHANE	62.9	PC	2, 5-DIMETHYL-HEPTANE	293.3	CEC	(E)-2-NONENAL	6.2

Fig. 13 Top 5 compounds at RB-FC Deposition Site, Bank Site, Upland Site and SW.

Flint River- BFFR #2: Brian Fork											
Dep-031A	Compounds	Conc	Bk-032A	Compounds	Conc	Up-033A	Compounds	Conc	002A	Compounds	Conc
PC	2, 5-DIMETHYL-HEPTANE	396.2	PPCP	TRICYCLO [4.3.0.07,9] NONANE	1136.1	PC	PENTADECANE	965.8	PPCP	(E)-2-PENTENAL	17.9
VOC	4-HYDROXY-4-MET-2-PENTANONE	289.6	PPCP	.ALPHA.-1-NAPHTHALENEPROPANOL	600.1	PPCP	1, 2, 3, 5, 6,7, 8, 8A-OC-AZULENE	776.5	PPCP	2, 3, 4-TRIMETHYL-2-PENTENE	7.2
PC	2, 6-DIMETHYL-HEPTANE	258.6	PC	HEXACOSANE	350.8	CEC	DIMER-CYCLOOCTENONE	713.3	PPCP	3-METHYLENEPENTANE	6.2
PPCP	2-METHYL-, 2-PROPANOIC ACID	200.1	UK	UNKNOWN	310.7	PPCP	1, 2, 3, 5, 6,7, 8, 8, NAPHTHALENE	450.4	PPCP	3, 5-DIMETHYL-1-HEXENE	5.4
PC	2, 6-DIMETHYL-HEPTANE	153.1	VOC	4-HYDROXY-4-MET-2-PENTANONE	237.4	PPCP	3, 8-DIMETHYLDECANE	410.1	CEC	3-METHYL-, CARBON-1-BUTANOL	5.2

Fig. 14 Top 5 compounds at BF-FR Deposition Site, Bank Site, Upland Site and SW.

4. Conclusion

Given the widespread detection of PPCPs and VOCs at these watersheds, these pollutants are not transitory and pose an environmental risk to human and aquatic animals in both the Flint Creek and Flint River. Therefore, high dilution is not adequate to mitigate the risk from this cocktail of PPCPs, VOCs and CECs. And the potential ecological risk for large watershed systems such as in North Alabama is much higher than previously understood.

PPCPs enter the environment in large part from improper disposal of medicines, illicit drugs or personal care products. Considering that PPCPs are the largest contaminant group in both Flint Creek and Flint River, Morgan, Cullman and Madison County residents are largely contributing to the pollution of their water supply, likely without even knowing it. Pollution by way of PPCPs is unavoidable (some personal care products have nowhere to go other than into our watersheds), however, the impact can be minimized by properly disposing of unused medicines and prescriptions at Drug Drop Box centers and Drug Take Back programs. In accordance with the One Health Initiative, PPCPs (and all contaminants) affect all humans, all animals and all plants in the world. By properly disposing of unused PPCPs at local Drug Drop Boxes and Drug Take Backs, strives can be made to protect not only Northern Alabama, but the entire Tennessee Watershed. Overall, this study indicated that the drugs and petroleum products are discharged due to erosion from all areas along the rivers and Huntsville STP (Sewage Treatment Plant) at concentrations that are at least equivalent, if not higher than concentrations in STP effluents sampled at Hobbs Road in Flint River. Several of these compounds were present at low and above concentrations of environmental concern in surface waters and depositional sediments near the STP. Fish exposed to pharmaceuticals and other organic compounds in surface waters near STPs could be negatively impacted. These data are enough to warrant further investigations into the distribution of pharmaceuticals and other organic compounds in

North Alabama watersheds and their potential effects on aquatic species because pharmaceuticals and personal care products were found in the Flint Creek above concentrations of environmental concern.

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Author Contributions

Material preparation was performed by P.O. and K.G. (Paul Okweye) whereas the first draft of the manuscript was written by P.O. and K.G. (Karnita Garner). All authors commented on previous versions of the manuscript. P.O., M. H., N. S. and Z.M. (Mackenzie Hutchinson, Nikita Sheeley and Zari McCullers) performed writing—review, and editing, and P.O. (Paul Okweye) supervised the work and reviewed the final version of the manuscript. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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